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THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

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TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, 14, Trinity Square, London, E.C. 3, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

THE PRINCIPAL'S REPORT.* 1931-1932.

THE prolonged world depression made the past year a particularly anxious one for the College and like many other institutions of its kind, which depend on annual contributions, it suffered from dwindling sources of revenue. Through various sacrifices, however, which included drastic cuts in Departmental budgets and voluntary contributions by members of the Staff towards College funds, and the welcome help of a munificent donation of £32,000 from the Carnegie Corporation, the budget was eventually balanced. The interest on the latter benefaction, which has been received as a first contribution towards an Endowment Fund will be devoted to the maintenance of the Chair of Agricultural Economics and of the Library and Publications Departments. Many of the economies effected left the Departments on a maintenance basis which will, for the present, at least, prevent them from materially extending their activities. Despite these difficulties, however, the year under review represented a record of satisfactory progress and a further consolidation of the College's activities as an advisory, training and research centre.

The College, through its Advisory Department, continued to keep in close touch with the agricultural services of the Leeward Islands and of St. Lucia and St. Vincent, and for this purpose a number of visits were paid by both the Commissioner and Assistant Commissioner of Agriculture. Among the more recent developments were the appointment of an officer to study the life history of the arrowroot leaf-roller in St. Vincent and a study, by the Marketing Officer, of the market facilities in Canada for West Indian fruit and vegetable produce. As a result of a Cotton Conference held in Barbados plans were formulated for a West Indian Cotton Growers' Association. In addition, a number of visits were arranged, including that of the Cotton Adviser to Barbados, St. Vincent and Montserrat, and of members of the College Staff to Antigua, where a survey of sugar-cane soils was made, and to St. Vincent, where arrowroot problems were investigated. Although the Advisory Department's work is mainly of an administrative nature it has always endeavoured to watch the agricultural interests of the group of islands under its charge and it is largely through its efforts that the fruit and vegetable industry, has been co-ordinated.

* Imperial College of Tropical Agriculture. The Principal's Report for the year 1931-32 and the Accounts for the year ended 31st August, 1932.

There were, during the Session under review, forty-five students in residence, of whom eighteen were Diploma students and twenty-five Post Graduates, the remaining two taking special courses. The curricula of the courses were not altered materially but preliminary steps were taken to revise the Diploma course with a view to designing a two year course, leading to a certificate, for the needs of planters' sons and of others seeking careers on the land. The details of the scheme for this new course will be announced as soon as they have been approved by the Governing Body. The past experiences gained in the conduct of the Associateship examinations were collated in the form of regulations which now form part of the new Prospectus.

As in previous years the research programme was confined mainly to cacao, bananas, sugar-cane and citrus.

With the initiation, two years ago, of the Cacao Research Scheme new fields of investigation were explored. Broadly speaking, the work was undertaken with the object of collecting information, both from the botanical and chemical aspects, to improve the yield and quality of cacao. So far, the botanical investigations have included an examination of various methods of vegetative propagation, observations on the degree of cross fertilisation and a genetic survey of the cacao population of Trinidad. In the preliminary experiments promising results were obtained for vegetative propagation by soft wood cuttings and layering while useful data were collected on the periodicity of the cacao tree and the relationship between vegetative growth, flowering and fruit setting and other physiological problems. The chemical aspect of the work concerned itself with an environmental study of cacao grown on a "good" and "bad" site. This investigation has shown a marked difference between the two sites as regard the carbon-nitrogen ratio, available phosphate and moisture relations. Previous work done by the Chemistry Department on the soils of Tobago, Trinidad and Grenada has indicated further that there is a general deficiency of available phosphate in low bearing soils while more recently pot experiments with tomatoes for testing soil phosphate deficiency, yielded hopeful results. Working in close co-operation with the Chemistry and Botany Departments, the Department of Economics carried out a combined soil and economic examination of certain cacao fields in the Montserrat district of Trinidad, with the object of ascertaining the effect of soil and age on the profitableness of cacao estates.

The Banana Research programme included a continuation of the investigations at the College Low Temperature Station on the control of wastage in bananas during storage, particular attention being paid to time and temperature factors and to the influence of rapid cooling on disease control. In addition, preliminary experiments on gas storage were commenced. Both officers attached to the Banana Research Scheme visited the banana plantations of a British Company in Brazil where they investigated an outbreak of disease. As a result of this visit they were able to advise as to the best methods of control. The banana breeding work which is being carried out by the Botany Department was confined to the collection of varieties and to varietal and cytological studies. The total number of pollinations made between September 1927 and January 1932 was 2461, from which 1735 bunches were reaped and examined for seed. Eight fresh introductions, including some tall sports of Cavendish from the Canary Islands were added while several interesting species of wild bananas, including one each from New Guinea and Samoa, flowered during the year. As a result of varietal studies the number of seedless types was reduced from eighty to fifty-three.

Sugar-cane investigations covered variety trials of thin canes, a soil survey of the Antigua cane soils, and extensive fertility, liming and manurial experiments in Trinidad. Of these experiments perhaps one of the most interesting is that concerned with the comparison of artificial with pen manures, its results having already influenced the local attitude towards the relative value of these two classes of fertilisers. Experiments with fertilisers alone, moreover, showed the need, according to soil type, for a very carefully balanced N.P.K. ratio. In connection with the froghopper pest problem a close study was made of the effectiveness of a new egg parasite and further data were collected on the incidence of other parasites and predators. A rapid method for enumerating the number of eggs in a soil sample was devised which will be used to determine the most likely areas of froghopper outbreak as a guide to the dry weather programme. The Sugar Technology Department carried out investigations on the exhaustion of final molasses, and on the hydrolisis of bagacillo during clarification under laboratory conditions, and completed an analysis of milling results obtained during the previous crop.

Other crops to which attention was paid were tobacco, tomatoes, papaw, cow-peas and various legumes. Some of the chief problems connected with the cultivation of tobacco were studied, especially by Post Graduates, working under the supervision of the College Department of Agriculture. This Department also carried out a series of experiments with legumes which were used as indicators in connection with suspected cases of potash deficiency. Definite information on the keeping qualities of different varieties of tomatoes during storage were obtained by the Low Temperature Station whose results revealed that tomatoes should be picked full-grown

but green, and held at pre-cooling stations and during transport aboard ships at 47·5°F. with subsequent ripening at 70°F.

The Department of Mycology investigated the effectiveness of a new spray. It also carried out a survey of tomato diseases and did work on a leaf spotting disease of ginger and on sour orange 'scab'. The fruit rotting of papaw was studied under field conditions and the work on the virus disease of this plant continued. So far, however, the insect vector of the disease remains unknown.

The Department of Chemistry, in collaboration with the Trinidad Forestry Department, made studies of forest soils in connection with the problem of soil deterioration in the tropics. It is hoped that the results will give greater definition to the C/N relationship which seems to decide partly, at any rate, the productivity of cacao soils.

From this brief survey it may be accepted that definite progress has been achieved during the past year in all of the several College activities, the research work, in particular, having produced results capable of practical interpretation. As time goes on it may confidently be anticipated that the continued collection of data will yield further information of practical value, not only to local interests but also to other tropical colonies in the Empire.

STRIPE DISEASE OF CORN (*ZEA MAYS*, L.) IN TRINIDAD.

By H. R. Briton-Jones.

Introduction.

In 1929 attention was drawn to a disease of corn which was causing a great deal of damage on the College farm and elsewhere in Trinidad. During that year, the crops, which were sown in December, were almost completely destroyed. The disease has since been prevalent on all corn crops grown on the above farm. Prior to 1929 there is no record of the disease but it is more than probable that it was present before that time. Maize is not an important crop in this island, being grown only on small areas, and this fact probably explains why the disease had not previously received attention.

In order to study the disease under natural conditions a differential sowing experiment was laid down in 1930 on the Mycological plot at the College. The dates of sowing extended from October 15th, which is about the middle of the wet season, to January 7th, when the dry season may be expected to begin. It was hoped by this means to correlate the incidence of the disease with the type of weather prevailing during the life of the crop; to obtain a supply of affected material at every stage of development; and to obtain a clear conception of the various symptoms of the disease which were known to be extremely variable and complex in nature. Unfortunately the later sowings were subjected to severe drought which prohibited successful growth and rendered disease observations valueless. On the other hand, the disease was found to be widespread on the earlier sowings in the experimental field as well as on the maize crops elsewhere on the farm. The number of plants affected in various degrees in the first three sowings varied from 30 to 48 per cent.

Symptoms.

The most definite symptoms are to be seen soon after the silks appear, and consist of a striping of the leaves followed by withering and premature death of the whole plant. The stripes consist of bands of lighter coloured tissue running the length of the lamina, and occupying the area between the major veins. The lighter coloured tissues vary in width from thin hair lines to bands which almost completely involve the whole leaf surface excluding the midrib. Affected leaves generally wither from the tip backwards and from the margin inwards, the lighter coloured tissue being first affected and turning either a dead-brown, or, in some instances, passing through a preliminary deep red or purplish-red phase of colour. This condition is not confined to weakly plants but is often seen on the most vigorous. In severe cases, as a result of premature withering of the leaves, the grain fails to fill out and the cobs are frequently worthless. In some instances the cobs exhibit a foliaceous form resulting from outgrowths of the rudimentary leaves composing the husk. These also show the characteristic light-coloured striping.

Very frequently the disease becomes apparent before tasseling. Plants may be seen which are stunted, with shortened internodes, and a bunch of leaves at the top. These are light in colour, the lightness being located chiefly in broad, almost etiolated bands running the length of the leaf and separated by narrower dark bands marking the position of the larger veins. This condition is frequently accompanied by a crinkling or frilling towards the base of the lamina. The head of the plant instead of being upright frequently bends over to one side (Fig. 7). Subsequently the upper leaves, and later the whole plant, gradually wither and this may occur either before the tassel appears or soon after its emergence.

Sections through the red areas on the leaves showed that the discolouration was associated with changes in the chloroplasts. The plastids in the palisade cells of the discoloured tissue were seen to be broken down into granular masses. The walls of some of the mesophyll cells showed signs of dissolution. From the outset the disease

was considered to be due to a virus but microscopical and cultural work has been done to show that there is no organism, whether of fungal or of bacterial nature, associated with the disease.

Several virus diseases of maize are known in other countries but none of the symptoms and illustrations given in the various publications referred to showed similarity to the disease as known in Trinidad with the exception of Stahl's (7) account of the virus disease known as the Stripe disease of corn in Cuba of which *Peregrinus maidis* is the vector*. Stahl's description and illustrations agreed closely with the symptoms on a large number of diseased plants found in Trinidad. Furthermore, *Peregrinus maidis* is very common on young maize until the tassel is produced when the insect leaves the plant. Stahl, on the other hand, makes no mention of any reddish or reddish-purple discolouration of the leaves of the affected plants which is manifested on a good proportion of diseased plants in this island. Trinidad maize is a heterogeneous mixture of varieties so that the development of reddish discolouration might be due to one of two causes or a combination of these, namely: varietal characteristic and/or the influence of weather conditions on the rate of development of the symptoms. Furthermore, the width of the stripes has since been found to depend largely on the number of *Peregrinus maidis* feeding on the affected plants. Those heavily infested with the insect develop broader stripes than those lightly attacked. In order, however, to clear the point the writer wrote to Cuba asking for information as to whether diseased plants sometimes developed a red discolouration and pointing out the difficulty of getting a clear definition of symptoms in our very mixed varieties of maize. In his reply Dr. C. N. Priode, Pathologist at the Estacion Experimental at Cuba gives the following interesting information: "The disease is very destructive here in Cuba and is very widely distributed. When plants are attacked very young they usually are a total loss, due to the fact that they either are killed outright or become stunted and cease to grow. In some cases the leaves do not unroll but curl up in a rope-like fashion and bend to the ground. In other cases the leaves form a bunchy rosette-like growth and further development ceases. Sometimes the plants which are only mildly attacked or which become infected in the later stages of growth will grow on to maturity with little evidence of damage, but in the majority of cases affected plants will show different degrees of damage from a complete dying out to only moderate stunting of growth".

"The symptoms on the leaves appear as three distinct types of striping but which appear to cause about equal damage to the affected plants. Whether these different types of striping are due to different strains of the virus, I cannot say. I have observed all three types on plants of the same variety in the same field. These different stripes may be due to different manifestations of the same virus, for in some cases I have observed plants which showed traces of all three types of stripes. I have not observed the reddening of the tissues which you mention in this letter except in certain cases a slight reddening appears as the tissues become necrotic and die. Such reddening as you mention, however, might be a varietal characteristic, or perhaps due to weather or other environmental conditions."

"For convenience I have described the different symptoms as types I, II and III as follows:— *Type I.*—Stripes due to a whitening of leaf veins both large and small, very fine and close together, usually extending full length of leaf but in some cases they fade into short stripes or dots at varying lengths. In some cases all the veins in a leaf may be uniformly affected, while on others only a few veins on one or both sides become chlorotic. In extreme cases affected tissues become necrotic. Stripes may be seen on sheaths, ear-husks and stalks. *Type II.*—The symptoms of this type appear as distinct, coarse, parallel stripes due to whitening of the large leaf veins, the smaller veins and interveinal tissues usually remaining green. Stripes usually extend full length of leaf. May show plainly on sheath, ear-husks and stalk. *Type III.*—Symptoms show as broad chlorotic bands rather than distinct stripes. Both the veins and interveinal tissues affected. Bands may extend full length of leaf but usually fade into series of dots or stipple stripes at different lengths on the leaves. In some cases the entire leaf bases are affected from side to side, while in others one or more broad bands appear on one or both sides of midrib. Bands sometimes follow along midrib. Symptoms in some cases are somewhat similar in appearance to grass mosaic. Also observed on stalk, sheath and ear-husks."

The photographs accompanying the above description from Cuba are reproduced as Figs. 1, 2, 3 and 4 and should be compared with Figs. 5, 6 and 7, taken in Trinidad.

Observations and Experiments.

Observations of maize crops showed the presence of the disease in the field at such a young stage that seed transmission of the virus was suspected. To discover whether this was the case several hundreds of seedlings have been grown, both in the field and in pots indoors, from seed collected from both healthy and diseased plants. A small percentage of all these lots of seedlings showed chlorotic symptoms but on close observation the symptoms were found to be distinct from those of Stripe disease. The manifestation of albino seedlings in maize is not uncommon and is a hereditary factor. The

* Storey (10) recently mentions a disease of maize occurring in the Amani district which is transmitted by *Peregrinus maidis* and possibly identical with that investigated by Stahl in Cuba.

STRIPE DISEASE OF CORN—(CUBA).

Fig. I.—Fine Striping. (*Type No.* 1).

Fig. I I.—Coarse Striping. (*Type No.* 2).

STRIPE DISEASE OF CORN—(CUBA).

Fig. III.—Chlorotic band type of striping (Type No. 3).

Fig. IV.—Diseased plant in early stages of growth.

following figures show the age at which young maize plants become infected and the rate of increase for the first few weeks.

No. of Field.	No. of Days after Sowing Date.	Percentage Diseased Plants.
I.	7	nil.
	28	0.2 per cent.
II.	21	0.3 do.
	35	0.9 do.
III.	28	0.3 do.
	42	1.2 do.
IV.	42	2.5 do.

Further observations were not possible because plants had to be thinned out so as not to interfere with the purposes for which the fields were sown.

All attempts to reproduce the symptoms of Stripe disease by artificial inoculation from a diseased to a healthy leaf have failed. Nevertheless, whilst admitting the possibility of a virus being present it would appear that the insect vector is essential for spreading the disease.

In an attempt to prove the relation of *Peregrinus maidis* with Stripe disease in Trinidad, as had been previously demonstrated by Stahl (7) in Cuba, maize seed from healthy plants were sown in pots containing compost and grown in insect-proof cages. Any seedlings which showed abnormal leaf markings were removed and numbers of both adults and nymphs of *Peregrinus maidis*, collected from diseased plants in the field, were placed on plants growing in one of the cages whilst the plants growing in another cage were kept as controls. Some of the insects died within a day or two of being transferred to the plants in the cage whilst many others lived, fed on the plants, and bred freely. The result of the experiment was completely negative since both the inoculated and control plants grew healthily until they reached the top of the cage. It was decided, therefore, to sow seed in the field and in the caged pots at fortnighly intervals. By this means it was possible to collect insects from diseased plants in the field at regular intervals in order to inoculate the young plants as they grew inside the cage. This was systematically done for several months but not a single inoculated or control plant showed any symptoms of Stripe disease. The cages used in this experiment were constructed of wood and close-meshed copper wire and it was thought that possibly the shading effect on the plants might cause a masking of the disease symptoms. This sometimes happens in the case of plants affected by true Mosaic, particularly if the inoculated plants are well supplied with nitrogen and other nutrient requirements as were the above maize plants. Larger cages were, therefore, constructed using mosquito netting instead of the copper-wire gauze so as to allow of better lighting for the plants. The use of a larger number of pots was thus possible and since there was not sufficient compost available some of the pots were filled with soil from a plot of poor unmanured soil. When the maize plants grown in these pots had reached a height of a few inches, numbers of the adults and nymphs of *Peregrinus maidis* were collected in the field as before and placed on the plants in one cage. A control was kept as before. On the twelfth day after the date of inoculation two of the inoculated plants in poor soil showed striping similar to that shown by some of the diseased plants in the field. None of the plants growing in the pots containing compost, though fed upon by numbers of *Peregrinus maidis*, showed any symptoms of disease. A further inoculation experiment was then set up using pots containing compost only and although large numbers of insects were feeding on the plants growing in these pots none developed any striping or other abnormality on the leaves. The results obtained in the foregoing experiments gave a clue as to how to obtain experimentally a manifestation of the symptoms of the disease. In a third experiment, therefore, four tins containing poor soil and two tins containing compost were used in both the inoculated and control. In this case one plant which was growing in poor soil showed typical striping of the leaves on the twenty-first day after the date of inoculation. A portion of each of two of the leaves of this plant is shown in Fig. 5.

An explanation of the above cannot be given. It is true that in the field, maize, growing in well known poor patches of soil in the Mycological plot, is more badly affected than plants grown on richer areas, but nevertheless very well grown maize plants in this plot and elsewhere on College land can be and often are badly affected by Stripe disease. Knowledge of the manurial treatments given to crops of maize which have become badly affected with Stripe disease suggests that if there is any relation between soil deficiency and the incidence of the disease, then this deficiency is rather more subtle than the more obvious Nitrogen, Phosphate or Potash. An explanation of the results obtained in the above infection experiments is of great practical importance and an attempt is now being made to solve the difficulty. For the purpose, both pot and field manurial experiments are being carried out in order to compare the influence of organic and inorganic manures on the incidence of the disease.

Control Measures.

As already stated by the writer (3) it is proposed to carry out experiments with a contact insecticide known as "Sulphemulsol" against the insect *Peregrinus maidis*. Whether the use of this spray fluid at two per cent. to kill the insect on contact, followed almost immediately by spraying with water to prevent damage to the plants, will prove a practicable measure, is a matter for further investigation. It is certain, however, that this spray fluid can be made use of in keeping down insect population. Young maize plants affected by Stripe disease can be easily recognised in the field and since it is known that these give

no crop there is no point in keeping them alive. Furthermore, if dealt with at an early date the numerous individuals of *Peregrinus maidis* infesting such plants can be killed and the plant destroyed by the simple operation of spraying a jet of "Sulphemulsol" down the funnel formed by the younger leaves.

The other method of controlling this disease is to decide on a closed season for maize at least on the College farm. When this should be done has not been decided since it is necessary, in order to obtain the optimum results, first to make a detailed study of the habits and life history of *Peregrinus maidis*.

A disease, the symptoms of which closely agree with those of Stripe disease of corn, has recently been found affecting millet (*Andropogon Sorghum*). As in the case of corn the insect *Peregrinus maidis* is closely associated with the disease which is now under investigation.

Acknowledgments.

The present account of Stripe disease in Trinidad is based on work done by L. N. H. Larter, T. Russell and R. E. D. Baker as Post-Graduates under my supervision. Full use has been made of their dissertations on the subject and I, therefore, desire to make full acknowledgment of their co-operation. My thanks are due to Dr. C. N. Priode, Pathologist at the Estacion Experimental at Cuba for his ready response to a request for further information on Stripe disease in Cuba and the excellent photographs showing variation in symptoms of the disease. His generosity in allowing me to make any use of both information and photographs I very much appreciated.

The photographs of the disease as it occurs in Trinidad have been taken by Mr. A. K. Briant, Lecturer in Mycology at this College.

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STANDARDIZATION OF CITRUS.

THE search for new markets which is being undertaken by many countries, particularly in the Tropics, whose Citrus industry is as yet comparatively undeveloped, involves as an essential corollary very thorough standardization of exported produce. Consequently the planter must pay the closest attention to a similar standardization of his planting material if he is to be a succesful competitor. The problem is one of first-rate importance; it is being approached from many angles by investigators in different parts of the world with varying success, so that to the worker in any one of these spheres of activity, no less to the planter, the publication* under review will be of the greatest value. The purpose of the Communication is, as Mr. R. G. Hatton, Director of the Imperial Bureau, explains in a Foreword, to collate the most recent work on the subject, stressing particularly experimental method and the lines of approach giving promise of greatest success. The present note is an attempt more to summarise the present situation and the prospects of the future than to select any specific problems from the wealth of data which this publication presents.

* "Investigations on the Standardization of Citrus Trees by Propagation Methods"—*Imp. Bur. Fruit Production. Tech. Comm.* 3.

The subject is treated under five main headings, viz.: I. Variation, II. Polyembryony, III. Vegetative Propagation, IV. The Scion, V. Rootstocks.

I. Variation.

From the records of commercial orchards, particularly in the United States, the existence of variation is shown to be incontrovertible, and a factor of greatest moment to the producer. Webber attributes this variation principally to the following causes: "1. Variations inherent in the buds due to different heritage. 2. Different kinds and characters of stock used. 3. The character of the union obtained in the budding and grafting. 4. Differences in environment. 5. Accident". His conclusion that stock influence is the fundamental factor appears to be in common with the views of other observers. With environmental causes we are not here concerned, and variability in scion material is normally a negligible factor as compared with that of the rootstock; so that the problem with Citrus, as with other perennial crops in which bud-mutations are more infrequent, is primarily the need of raising uniform, clonal rootstocks.

II. Polyembryony.

The widespread occurrence of polyembryony as a phenomenon in Citrus would at first sight seem likely to provide an adequate excuse for raising seedling rootstocks, the method at present universally adopted. The mode of origin of seedlings from polyembryonic seeds is, from a cytological standpoint, strictly analogous to vegetative propagation.

The vegetative (asexual) embryos arise by the differentiation of certain (nucellar) cells of the mother plant, unaccompanied by any sexual process in which the genetical make-up of the resulting seedling might conceivably be changed from that of the parent plant from which it arose. Such vegetative seedlings must therefore have all the characteristics of the female parent, though the work of Toxopeus has shown that the stimulus of pollination (not necessarily fertilisation) may be an essential precursor to polyembryony. The frequency of occurrence of this phenomenon bears an obvious relation to the uniformity of seedling populations. The percentage of polyembryonic seeds is found to fluctuate considerably both between different varieties and within strains of the same variety. This may in part be due to differences in the vigour of sexual seedlings and their survival rate relative to that of the vegetative embryos. In this connection it is particularly interesting to note that, in general, vegetative seedlings are more vigorous than sexual seedlings arising in the same seed, and tend to suppress them.

To be able satisfactorily to translate this natural process into a useful commercial practice, as has been suggested by various authorities, the need for a more thorough knowledge on two main points is evident—firstly a reliable means of recognising the sexual types and "roguing" them out; and secondly the factors which determine the rate of polyembryony.

The recognition of the sexual seedlings in species such as the Rough Lemon is claimed by Toxopeus to be a matter of comparative simplicity since he found there to be only about four per cent. which develop; but in the Japanese Citron (*C. nobilis Lour.*—hybrid) the percentage was as high as 50-60 per cent. rendering eye-observation a difficult matter. Though with practice such seedlings could be "rogued" with fair success it is suggested that confusion could be overcome by crossing with a male parent whose characters are sufficiently distinct from those of the mother plant as to be immediately recognised in the seedling. This raises an extremely interesting field for investigation, particularly in view of Webber's findings that generally speaking F1 hybrids exhibit a higher frequency of polyembryony than either of the parents, and the suitability of such plants as stocks on grounds of vigour.

Much remains to be learnt about this aspect of the problem, but there seems no doubt, on theoretical grounds at any rate, that we have here a possible method of raising clonal rootstocks more cheaply and with less readjustment of our present methods than the adoption of vegetative propagation by cuttings would necessarily incur.

III. Vegetative Propagation.

More or less successful attempts have been made to raise Citrus species by the majority of recognised methods, and the results are here summarised in some detail. The personal element, together with variations in the nature of the material used and the conditions of experiment, makes the assessment of the value of any one method a difficult problem. The difference between success and failure often lies in apparently small matters of technique employed by different investigators, the significance of which is not fully understood. It seems certain, however, that if any of these methods is to gain commercial importance—especially in tropical countries—it must imply simplicity, cheapness, and the capability of being applied by relatively unskilled labour. It is equally certain that no method at present evolved has succeeded in meeting those contingencies.

Quoting Halma—the advantages of trees raised vegetatively on their own roots are weighed against the disadvantages inherent in the method, as compared with trees budded to seedling stocks. The disadvantages are claimed to be the extra amount of planting material required and susceptibility to disease. Both these factors can be said to contribute largely to the success of budding, and it is felt that not even the claims of uniformity can outweigh the advantages of budding—the disease problem alone would render raising plants on their own roots impossible in the humid tropics. Further, the same degree of uniformity can be obtained without abolishing budding by making use of vegetative propagation as a means of obtaining clonal rootstocks. It is to this end that the subject should be explored.

In the West Indies the only stocks of importance are at present the Sour Orange and Rough Lemon, but pre-eminently the former of the two. It is to these two species that the enquiry must be directed, firstly to discover the most suitable technique for raising clonal material, and secondly to determine whether such vegetative rootstocks can claim any particular advantages or disadvantages over seedling material. It is to the root system that the study of this second problem should be principally addressed; we have no positive evidence of the oft-repeated claim that cuttings are intrinsically weaker in their root system than plants raised from seed.

As to the technique of propagation—it is at once apparent that there is considerable diversity of response in different Citrus varieties and species. The Citron (*C. medica* Linn.) and Lemon (*C. Limonia* Osbeck) groups are on the whole comparatively easy to root by most methods; whilst at the other extreme we have the Sour Orange and related types which are far less amenable to treatment. The sweet orange, lime, and grapefruit groups occupy as a rule an intermediate position. Such eminent authorities as Hume and Coit have affirmed that the rooting of oranges and grapefruit presents such difficulties as to be insurmountable in general practice. More recently, with improvements in technique—

such as in the use of the solar propagator—these species have been rooted successfully in a fairly high percentage of cases. An account of various methods and the success achieved by them has appeared recently in this Journal* and the conclusion is drawn that, with the aid of the solar propagator under Trinidad conditions, the semi-hardwood cutting and leaf cutting have given most satisfactory results. This is in general agreement with the results of other workers, but the disparity between results with semi-hardwood cuttings is shown to be very wide in the hands of independent workers. The greatest response achieved with sour orange by this method is 92 per cent. rooted in 60-90 days—obtained by Halma under Californian conditions with the aid of a propagating pit. Hunter—in Trinidad, using the solar propagator—obtained 40 per cent in 60 days; while Oppenheim in Palestine obtained 1.6 per cent. and 25 per cent. in two trials, both conducted in the open. These discrepant results only serve to indicate the need for carefully-controlled experiments under local conditions, but are encouraging inasmuch as they show that the sour orange does not possess any inherent disability to form roots. Choice of the right type of material, and of the most suitable environment for callusing and rooting must both receive the closest attention.

The use of leaf cuttings gives promise of useful results, though so far it has received but little attention. Hunter using leaves with the bud and a small slip of stem attached, has achieved equal success by this method as with semi-hardwood cuttings; so that with the advantages of economy in material and in space in the rooting bed which this method implies, there is fair promise of its application on a larger scale. It must be admitted, however, that it is too early to argue from the results of these preliminary trials, and they should merely be regarded as pointers towards a more general understanding of the processes involved. The ideal propagating medium has not yet been found, and the solar propagator has not conclusively proved its usefulness in the Tropics.

The successful multiplication of plants in the field by layers or stools is a necessary sequel to raising cuttings. Comparatively little has been achieved in this respect. Layering has been applied in Java with a similar technique to that employed at East Malling for apple stocks and other deciduous fruits. Year-old material is planted at an angle of 40° with the ground, and when established bent over and pegged to the bottom of a shallow trench running along the row. As the buds swell they are lightly covered with an inch of soil, and subsequent earthing up is done to keep pace with the growth of the shoot. The initial mounding must be light in order to get the buds to break, but roots will only form if the base of the shoot is completely etiolated.

* Hunter, R. E.—*Tropical Agriculture*, Vol. IX, No. 5, 1932.

The "Dahlem wiring method" is described as a successful application of stooling, and consists essentially of encouraging root formation at the base of the etiolated shoot by strangulation with wire wound round it about 15 cms. below the surface of the heaped earth. Sour orange responded to this treatment, but not to normal stooling without wiring. Buds of Citrus species generally appear to be susceptible to pressure of earth upon them, so that earthing up before they break is often fatal. The growing point must therefore be kept free so far as is compatible with proper etiolation of the basal part of the shoot.

Marcottage is a method of propagation successful with all varieties, but is too cumbersome and costly to become a standard commercial practice.

IV. The Scion.

Careful bud-selection from desirable trees together with the recognition and replacement of off-type trees in the orchard have been shown to be necessary for the maintenance of yield and quality; more especially is this so with Citrus, where bud-mutations are of relatively frequent occurrence.

Bud-mutations assert themselves usually as limb variations involving change in the habit, shape and quality of the fruit, yield, time of ripening, and in other ways. American workers have established such types in all the most important citrus crops. In the Marsh grapefruit, for example, five "strains" were recognised as having arisen in this manner, namely:—Marsh, Alternate-bearing, Rough-seedy, Smooth-seedy, and Unproductive—and in the great majority of cases those characteristics were reproduced in their vegetative progeny. This is the only sure test of a bud-mutation, and is necessary in order to eliminate the possible effect of environment on habit and other tree characteristics.

Generally speaking bud-mutations involve a trend towards inferior types, but where superior characters appear it is possible for them to be put to commercial use by propagation. This is not without its difficulties, however, and considerable caution is needed. In particular the danger of "reversion" to the original type has to be recognised, and cases of its occurrence are on record.

The fact that in Californian Navel orchards 25 per cent. of the trees were found to be off-type—to quote an isolated case from Shamel—emphasises the need for regarding bud-mutations as a source of variability and loss in yield or quality, rather than as a potential source of improved types.

V. Rootstocks.

The concluding pages of the Communication are devoted to a full discussion of the merits of different species of Citrus and allied genera as stocks, particularly in relation to their compatibility, root-systems, effect on scion, and disease resistance. A useful table summarises these

views in respect to the most important stock varieties, and together with other valuable information collected from widespread sources forms a topic worthy of close attention.

In spite of the numerous species which have been tried as stocks in different parts of the world, our knowledge of their specific attributes is still very scanty. The stock-scion relation has still to be brought down to more precise terms if we are to employ our stocks most profitably. Obviously this wide problem can be studied to better advantage when it is found possible to raise the stocks vegetatively, and eliminate seedling variability; but at the same time preliminary observations can simplify future work, and is an aspect demanding the fullest study. Standardization of rootstock material is obviously useless unless we are sure of what we are propagating, and confident that it is giving the best results that the climate allows.

This publication will, it is felt, amply repay the labours of the Officers of the Bureau concerned in its compilation by its widespread appeal to everyone interested in Citrus production—whether planter or research worker. To the latter it will be an invaluable work of reference (a full bibliography of 101 titles is appended) and a useful guide for future investigation; to the planter it should appeal if only he is to realise the possible improvements to be gained by standardizing his planting material.

N. W.

MISCELLANEOUS NOTES.

Control of Fiji Pests and Weeds.

Of forty-five beneficial insects introduced into Fiji, the following have proved of particular value: *Ceromasia sphenophori*, Villen., introduced against *Rhabdocnemis obscura*, Boisd. (cane borer); *Plaesius javanus*, Er., against *Cosmopolites sordidus*, Germ. (banana borer); *Ptychomyia remota*, Aldr., against *Levuana iridescens*, Beth-Bak. (coconut moth); *Cryptognatha nodiceps*, Mshl., against *Aspidiotus destructor*, Sign. (coconut scale); and *Liothrips urichi*, Karny, against the weed, *Clidemia hirta*.

An inspection of areas in which *Liothrips urichi*, Karny, has been colonised on *Clidemia hirta* showed that the results of the liberations have been in general most encouraging. The weed when once attacked by the thrips becomes stunted and is soon over-run by other rapid-growing plants, which eventually kill it.—(*Review of Applied Entomology*, Vol. XX, Series A., Part 12.)

* * *

Trinidad Mora.*

Mora (*Mora excelsa* Benth = *Dimorphandra mora* B. & H.) is a large evergreen tree reaching a height of 150 feet and a diameter of three feet or so above buttresses. It grows in practically pure stands, a habit of growth unusual in the tropics. The largest forests of this tree in Trinidad are found in the Mayaro district where they are estimated to cover about 64,000 acres. Mora timber is hard, fairly heavy, tough and durable, and weighs when air dry about 63 lb. per cubic foot. Its colour varies from pale to reddish brown. Locally the timber is used for a variety of purposes including house building (chiefly scantling and floor boards), railway trucks and wagons, oilfield operations, lighter and boat building, bridging, decking, railway sleepers, &c. According to a recent report issued by the Forest Products Laboratories of Canada, Mora, for use as a post, is stated to have strength properties higher than any (Canadian) native wood. In view of its promising qualities as a timber, the Forest Products Research Laboratories, Princes Risborough, England, have undertaken investigations into its mechanical properties, working qualities and seasoning. There are in Trinidad one well equipped Mora sawmill and two smaller mills.

* * *

The Gros Beak.

A correspondent informs us that from June to October last year severe damage was caused in his garden at St. Augustine by a bird subsequently identified as the "Gros Beak" (*Saltator olivascens*). This bird, which has leaf eating habits, is well known in various localities in Trinidad where it generally occurs in small numbers. In this case, however, as many as fifteen to sixteen of them were seen together. From observations carried out by our correspondent it was ascertained that the birds not only ate the buds and growing points of peas and beans but also mature and young papaw (*Carica papaya*) leaves, papaw blossoms, very young papaw fruits, pepper (bird peppers and bonny peppers) and guava fruits. It is also believed that the depredations subsequently found on cucumbers, squash and christophines were traceable to the same source. These birds, which invaded the garden from a patch of thick bush several acres in extent, appeared to be most active for an hour or two about sunrise and just before sunset.

During November and December they were not observed and there appeared to be no damage done by them. A few were shot when the attack was at its worst and this was followed by placing bird "scares" in the papaw trees and in other conspicuous places. The "scares" were made of bits of tin suspended in the air, which, as they swung in the breeze, gave off flashes of reflected light. The attack may be seasonal and in that case the shooting and the use of "scares" may have had but little to do with the cessation of the damage.

* *Leaflet No. 5. Forest Department, Trinidad and Tobago.*

STUDIES IN TROPICAL LAND TENURE.

By H. Martin Leake, sc.d.

VIII.—The Sudan.

The term Sudan, in its earlier application, embraced an indefinite tract of country stretching across Africa. As now applied, the name has a definite territorial significance. It denotes that smaller, but still vast, stretch of country, covering about one million square miles, extending over some 18° latitude from Egypt to Uganda and some 20° longitude from the French Sahara to Eritrea and the Red Sea. In many respects the Sudan differs markedly from any of the countries hitherto considered. Dominion over the territory of a sufficiently firm character to permit of the establishment of a Civil Government was introduced little more than a generation ago, after a great part of the country had been devastated by the Dervishes under the Mahdi and the Khalifa. Climatically the territory offers marked contrasts. The northern part is practically a rainless desert and fertile only where the waters of the Nile, which traverses it throughout, reach. To the south the desert passes, in the neighbourhood of Khartoum, into a wide belt of seasonal rainfall of ever increasing intensity until there is reached in the extreme south a belt with conditions comparable to those of Uganda. This climatic diversity is surpassed by the diversity of its population. In the north is an Arab population, intensely Mohammedan in religion, intermingled with tribes of nomads, desert wanderers such as the Hadendowa in the east; south is a congeries of negroid and generally pagan tribes at very differing stages of development, the Shilluk, inhabiting the left bank of the Nile south of Kosti to the Sudd area, the Dinkas, the Nuers and the Nubans. In addition to this endemic population there is a considerable alien element composed of members of West African tribes, known locally under the collective name of Fellata. These belong to the Mohammedan tribes of West Africa and pass along the route for Mecca which cuts directly across the Sudan, crossing the Nile about Senaar and passing thence through Kassala to the Red Sea ports. Their journey occupies many years and whole families may rest *en route* for a series of years and, perhaps, on the return journey settle permanently. Kassala itself has a population largely of Fellata origin. Being cultivators, they settle where cultivable land is available or a demand for their services as labourers exists, and their presence is not without a bearing on the land problem.

The two major factors controlling and limiting the development of the Sudan when it was conquered were lack of population and facilities for transport. The country was at that time approached from Egypt by the waterway of the Nile and it was the northerly area of low rainfall which first attracted attention. Though the Dervish rebellion arose further south, its influence spread throughout this tract and some measure of the destruction wrought may be gathered from the fact that, before it was crushed, the population is estimated to have been reduced from 8.5 million to 1.8 million (1). Here lack of population is the dominant consideration. Further south the population increases in density though it is still low; but the only natural highway, the Nile, which reaches Lake No after passing from the south into the Sudd area, a region of swamp, leaves aside the higher lands of the Bahr el Gazal and other southern provinces which probably constitute the most fertile area of the whole Sudan. It is this fact that the drier areas were the first to attract attention, combined with a history closely linked with that of Egypt, itself a country dependent on irrigation, which has led to that courageous scheme of development to be mentioned later, the irrigation of the Gezira, and has left the naturally fertile lands further south hardly developed.

Contact between Egypt and the Sudan dates from very early times and for long the Sudan had been an adjunct of Egypt and governed by it, though the area so controlled was ill defined and the hold on the outposts none too certain. Mohammedanism had taken firm root in the north, especially among the Arab population and there is, perhaps, no more fanatical race to be found outside the Sudan. These two forces led to the establishment of a land policy based on the Koranic laws; it is a policy which is still the dominant feature of the country. In this, as in all Mohammedan countries, land is recognised as the property of the rulers and that recognition takes the form of a tax or tithe, 'ushur', equal to one-tenth of the produce. Here, as in Akbar's system in India, it is the productive capacity of the land rather than the land itself which is of account, and a classification of the land on a basis of that capacity is involved. But, in the absence of any pressure on the land, it is taxation rather than ownership that assumes the more important role. By the time the country became of practical interest to England the matter had become more complex. That interest was, in the first instance, an indirect one and sprang from England's intervention in the affairs of Egypt. An early account of the conditions as then existed is to be found in a report by Stewart (2). Though the tithe formed the basis of the assessment, it was compounded with other taxes such as those on houses, cattle, sheep, &c. Variable in amount from district to district, the sum, once fixed, was invariable and independent of the harvest. Each district was rated and the sum assessed distributed among communes, villages and so on until the individual cultivator

was reached. Payment was no longer made in kind but in money. To meet the case of that somewhat large nomad population, a tribal tax, based on head of cattle, was imposed. It was in Berber and Dongola that the system reached its fullest development. Here the influence of the lack of any pressure on the land becomes apparent, for the tax was levied, for the most part, not on cultivated area but on the implements of irrigation combined with productiveness of the land, with the qualification that one sakiya (water wheel) was calculated to irrigate eight acres, but, if it was used for a larger area, an extra tax was enforced. On this basis a somewhat complex series of taxes was evolved.

(1) per sakiya—4 classes, according to quality of land.

(2) per matara (well)—3 classes.

(3) per shadoof (bucket)—2 classes.

(4) per feddan (1.038 ac.)—3 classes; applied to islands planted on the fall of the Nile.

(5) per feddan—3 classes; applied to riverain (Gerouff) land.

(6) per feddan—5 classes; applied to the small areas sown on rains.

In addition to these taxes, a further tax of two piastres (5d.) was imposed on each date tree.

Shortly after Stewart submitted his report, the Dervish rebellion rendered the Sudan a closed area until 1897 when, after reconquest, a civil Government was established under a Governor-General. In that year a report was made on the Dongola Province by Dawkins (3). While in general agreement as to the system of taxation, he notes additionally that the area served by one sakiya is generally owned by several families or individuals, and he notes further that those cultivators who remained, were not disturbed by the Dervishes. It would appear, however, that considerable numbers had fled and that, if the Dervishes left the people, they commandeered the cattle, for shortage of cattle to work the sakiyas was one of the major difficulties which faced the Administration on reoccupation. Dawkins recommended the reinstatement of the fugitives if their return took place before the end of 1899.

So far, taxation formed the primary consideration of the Administration, but this was not long to remain so; for, in 1898, the first step in settling the land question was taken. In that year a notification was issued to all concerned pointing out the difficulties attaching to any grant of valid titles, and it was soon followed by other steps. The first two Ordinances (Ords. 1 and 2 of 1899) of the re-established Government deal with the question of titles to land, the third with that of the taxation of land. The first of the above deals with town land in Khartoum, Berber and Dongola; the second with land in general. Under ... power is taken to nominate District Commissions to determine questions of ownership and to establish a land register. The guiding principles to be adopted in deciding the validity of titles were:—

(1) five years continuous possession constitutes ownership and confers a valid title,

(2) possession since the re-establishment of the Civil Government creates a *prima facie* title in default of a superior one,

(3) where a superior claim is maintained against a possessor, the possessor is to be given a similar grant elsewhere.

To check exploitation, it was further laid down that—

(4) all cultivable land, whether cultivated or not, would be liable to taxation.

The Land Taxation Ordinance (Ord. 3 of 1899) introduced no new principle but, for very practical reasons, was only partially enforced while, as a provisional measure, payment was accepted in kind. As the report for 1901 (4) points out, abolition of collection in kind could only take place when development of communications opened up a market to the cultivator.

Further steps in the direction of settling the land question consisted in the gradual appointment of Land Commissions under the Ordinance, but progress was limited by the need for adequate survey and surveying staff. In 1905 was passed the Demarcation and Survey Ordinance (Ord. 9 of 1905) conferring adequate powers on the surveyors. Further legislation was passed in 1903 (Titles to Land Ordinance, No. 3) and in 1905 (Land Settlement Ordinance, No. 6) while the registration of titles was governed by the Deeds Registration Ordinances passed in 1907, 1908 and 1920 (Ord. 9 of 1907, Ord. 7 of 1908 and Ord. 5 of 1920). These Ordinances are all repealed by the comprehensive consolidating Land Settlement and Registration Ordinance (Ord. 23 of 1925). Under it all lands to which a claim is not established, become the property of Government. Settlement is still far from complete and the Ordinance of 1925 is of limited application, being confined to the areas scheduled in the Ordinance and to such other areas as are notified in the *Gazette*. At the present time practically the entire rains tract to the south remains unsettled. This large area remains as yet undeveloped; there is no pressure on the land and ownership is hardly recognized by the peoples. Such ownership as exists is tribal rather than individual.

Land taxation has undergone contemporaneously a like evolution and is now administered under a consolidating Taxation of Land and Date Trees Ordinance (Ord. 24 of 1925) which lays down ten grades of rates per feddan. Again, this Ordinance is only applicable to scheduled areas from which the southern Sudan is excluded. For rains lands, excluded from the main Ordinance, a special Taxation of Rainlands (Ushur) Ordinance (Ord. 15 of 1924) is in force which admits of payment in

kind as a permissible alternative to cash. This Ordinance, again, is of limited application and excludes the southern Sudan. In the absence of any land settlement in these southern Provinces, a hut and poll tax, governed by the Hut and Poll Tax Ordinance (Ord. 18 of 1925) is enforced.

It is hardly surprising that a country of such vast expanse, known to be thinly populated yet with large potential agricultural possibilities, should offer attractions to aliens, and it was not long before a demand of this nature arose following the reconquest. Moreover, it was a demand readily satisfied for, owing to the want of coinage, anyone possessing the wherewithal found ready sellers. The position was open to abuse and as early as 1900 the Government intervened with a Proclamation (*Gazette* No. 10 of 1900) notifying that, until such time as it might be found possible to establish a Land Register, all contracts for the purchase of land should be submitted to the Governor of the Province for approval and that all sales, the terms of which had not been so submitted would be revisable by the Land Commission. This Proclamation followed a Notification (*Gazette* No. 1 of 1899) drawing attention to the fact that no vendor of land was in a position to give a valid title, and it was followed by a further Proclamation (*Gazette* No. 78 of 1905) defining the position with greater precision. Any sale, mortgage charge or other disposition of any land or interest in the same without the consent of the Governor of the Province was rendered null and void, exception being granted in the case of devise by will or a lease of not more than three years. The position was finally regularized by the Natives Disposition of Lands Restriction Ordinance (Ord. 3 of 1918) which repealed the former Proclamations while laying down the same limitations. Latitude, however, is given to the Governor to consent at any time to disposals made in good faith without intention to conceal.

Largely owing to the paucity of the population and the consequent absence of any deeply rooted love of the land such as was responsible for the heart-burnings in the Gold Coast, the settlement of the land question, as far as native ownership is concerned, has been concluded. The general principles have been laid down and time is available for a gradual filling in of the detail. The main interest which attaches to the history of the land question lies elsewhere. As has been stated, the Northern Sudan, which was the most accessible and the first to attract attention, is a vast desert which, except for a few small tracts where a stray shower permits a precarious crop, is only cultivable along the narrow belt bordering the Nile. Here cultivation is conducted on the receding flood or on irrigation by sakiya or shadoof. In this tract an early development took the form of installing pumping stations on the banks of the Nile or on floating stages. From the pumping station the water is led into a canal system and conducted onto the fields by flow. The area commanded is limited by the extent of the commanded area or by the capacity of the pumps. Thus, of the series to be found in the Provinces of Khartoum, Berber and Dongola, that at Gendettu occupies approximately 3,000 feddans with a potential capacity of 3,500 feddans, while that at Bouga occupies approximately the same area. Prior to canalization the land was, for the most part, held on a peasant system of small holdings for which valid titles had been issued. Canalization here raised a series of problems of organization among a number of small and independent units, such problems as the rotation of supply of water and, since cotton formed with wheat the major crop, the organization of a seed supply and for marketing and ginning the produce. It is the problem of introducing a central authority where none existed before. These problems were met in some cases by the assumption of control through the direct agency of Government; in others, by indirect control through concessionaires. In both cases land, where in private ownership, was left in the hands of the owners with such minimum disturbance as the exigencies of canalization permitted; where uncultivated, and hence the property of Government, the land was divided into blocks of ten feddans and leased. For all, a water rate is charged which varies with the crop and, for cotton, is fixed at half the nett sale price. Cotton is selected for special treatment because the character of the plant requires the regulation of a seed supply and, unlike other crops, supplies a special market. That organization of a seed supply, as well as the shipment of the seed-cotton to Port Sudan for ginning and marketing, is one of the functions of the controlling authority.

These pumping schemes, however, in their totality, cover only a small area and greater interest attaches to that major example of co-ordinated development among peasant holders, the irrigation of the Gezira. The Gezira is that triangular tract of country lying between the Blue and the White Nile. It is a monotonously flat plain sloping gradually from south to north and from east to west and, therefore commanded by the Blue Nile. Rainfall is seasonal and precarious but permitted, with intermittent years of failure when famine supervened, the cultivation of 'dura' (*Sorghum*) and 'dukhn' (*Pennisetum*) by a system of terracing. The population was largely migratory and many resided only during the brief crop season. The tract to a great extent furnished the food supply of the Dervishes during the rebellion. The lie of the land admirably adapted the tract to irrigation and it is hardly surprising that its potentialities early attracted the attention of Government, staffed as it was by officers drawn from Egypt. Moreover, the flow of the two Niles to their southernmost limits had been the object of study to the irrigation officers of that country. Direct attention was first drawn to the possibility of irrigating the Gezira by the report of Sir William Garstin (5)

and from that foundation the scheme has been carried to fruition with an area of some 300,000 acres irrigated from the water retained by the Senaar dam thrown across the Blue Nile. It is not possible here to follow in detail the history of that project. It is to be found in a pamphlet published at the time of the opening of the canal system in 1926 (6). It includes, besides the dam itself, the completion of a railway running south from Khartoum and the institution of experimental areas to test the possibilities of extended cotton cultivation. The first of these areas was laid out in 1911 at Tayiba with an irrigated area of some 3,000 acres on land which was rented. A second pumping station was installed at Barakat in 1913 to irrigate 5,000 acres and was followed by the installation at El Hag Abdulla (19,500 acres) in 1921 and that at Wad el Nau (30,000 acres) in 1923, the primary object of the latter two being the training of the inspectorate staff required for the fully developed scheme then approaching completion.

The capital involved in the scheme was necessarily large, too large for a backward country just emerging from a state of anarchy, and arrangements were made with the Sudan Plantations Syndicate, a body already with experience on one of the pumping stations to which reference has already been made, under the terms of which it was entrusted with the control of the experimental areas at Tayiba and Barakat. The success of these initial experiments was such that the full scheme appeared justified and a more permanent arrangement was required. Under this, the Government undertook to finance the major works of building the dam and major canals for which a loan was raised with the guarantee of the British Government, while the Syndicate undertook to finance the minor canalization, general management and supervision of the cultivation and the marketing of the crop.

The background on which this superstructure was to be thrown was a vast tract with a scattered population cultivating irregular areas on a peasant holding basis. The system was ill adapted to canalization with its requirement of regularity of lay-out. Not the least of the problems presented was, thus, the adaptation, with equity to the interested owners, of the tenure system to the new conditions. The change obviously needed a detailed knowledge of the rights of the people in the land and for this a Land Settlement Commission was appointed in 1906, the work of which was completed in 1912 (7). Concurrently a cadastral survey was carried out and the country staked by iron poles, or beacons, set at minute intervals of latitude and longitude. In 1914 a Notification under the Proclamations of 1900 and 1905 (*Gazette* No. 247 of 1914) was issued in which Government expressly reserved the right to purchase or lease any lands in the Gezira at prices which had hitherto been current in the same locality without taking into account any increase in the value of the land accruing from any irrigation works which might be undertaken. By 1920 the scheme had taken definite shape and a Notice was issued to the affected landholders stating that:

(1) the present owner will not be deprived of his land,

(2) Government will hire all land within the area, paying rent for the same, but retains power to purchase all land occupied by permanent roads, canals, &c.,

(3) hiring will be for a term in the first place not exceeding forty years and rent will be fixed throughout the period,

(4) the land will be let annually to tenant cultivators under the system in force at Tayiba and Barakat and preference will be given to owners to take up such areas as they are capable of cultivating in this way on, or near their original holding,

(5) Government, while intending that hire should cease after forty years, reserve the right to extend the period,

(6) in assessing rent, no account will be taken of any rise in value caused by the scheme,

(7) tenants will be permitted to grow, besides cotton, sufficient 'dura' for their own food requirements but not for sale,

(8) owners will be permitted, as at present, to transfer or mortgage their rights of ownership to other natives of the same locality.

This Notification was implemented by the Gezira Land Ordinance (Ord. 12 of 1921), amended in 1923 and repealed by the Gezira Land Ordinance of 1927 (Ord. 6), fixing the rental at 10 piastres (2*s*.) per feddan and laying down the conditions of annual tenancy, carrying the right to renewal, namely:

(i) punctual payment of all sums payable,
(ii) the efficient cultivation according to the scheme laid down by the Government or its agents,
(iii) the assent of the Government to the transfer or sub-lease of any land with possession of any of the crop,
(iv) on failure to observe any of the conditions, Government is empowered to re-enter and the right of renewal becomes forfeit.

The practical development of the scheme involved the division of the land into 30-feddan holdings, each carrying a 'tukl' (homestead), ten feddans being under cotton with the other twenty fallow or with 'dura' and, possibly, a leguminous crop, giving a three-year rotation. The terms of the contract admit of a change in the rotational system and, in fact, this original system has been modified. To meet the case of owners of larger original holdings, these are given the right to cultivate one tenancy themselves and to nominate others up to the extent of their original holding. The regularity of the lay-out permits of mechanical ploughing and ridging for cotton which are performed by the Syndicate, all subsequent work to picking

and eradication of the crop being done by the tenant. The crop is taken over by the Syndicate for ginning and marketing and the nett proceeds were divided in the proportion of 35 per cent. to Government to meet the service of the loan, 25 per cent. to the Syndicate and 40 per cent. to the cultivators. Again these proportions are open to modification and have, in fact, been modified.

The administration of the scheme is in charge of the Syndicate as agents for Government and it employs for the purpose of supervision a number of inspectors. The original area was divided into 19 blocks but the number increases with the extension of the scheme. Each block is in charge of an inspector with two or three junior inspectors, and the 19 blocks formed three groups, each under a senior inspector. The function of these inspectors is the agricultural supervision; they have no punitive powers and the whole administrative structure is, thus, superimposed on, and works collaterally with, the Governmental administrative machine.

For the successful production of cotton of even staple, a highly organized seed supply is essential and the magnitude of the scheme is sufficient for the organization to carry as an overhead charge a seed farm, originally of 900 feddans, where strict attention is paid to maintenance of purity, and roguing is carried into the fields sown with the produce of the farm. Further, the intractable nature of the soil and the limiting conditions in general for the type of cotton, Sakel, grown, have raised numerous questions requiring research of a somewhat fundamental nature for their solution. Here, again, the organization is sufficiently large to carry, in conjunction with the Empire Cotton-Growing Corporation, a research station, and reports on the problems and on the work conducted appear annually (8). One further point of interest arises which has been the subject of much anxious consideration, the source of supply of the seasonal additional labour required, mainly for picking. So far the supply has been adequately met partly from the surrounding tracts of the White Nile, the Blue Nile and Darfur Provinces but particularly from the Fellata pilgrims of West African origin referred to above. But, as the tenants become more prosperous and less inclined to work themselves, there exists the danger of a shortage of supply which may become the limiting factor to an expansion of the area.

This brief account has not permitted a discussion of the numerous detailed problems, on the solution of which the success of the scheme depended. The methods by which they have been solved are, however, worthy of close study for the success is undoubted and offers a striking example of the potentialities underlying a triple partnership for production for export. It can hardly be doubted that the authors of the pamphlet of 1926 are correct in stating that the organization adopted has provided the only possible method by which a return could have been obtained on the large amount of capital that was ultimately required for the Gezira scheme (p. 10).

There are two further areas in this country of divergent conditions, which are so unique that they deserve brief mention. They are the two areas at Kassala, in the Kassala Province, and Tokar, in the Red Sea Province. Both are inland deltaic areas formed respectively by the rivers Gash and Baraka which debouch from the Eritrean hills and, without reaching the sea, spread a seasonal flood on which cotton is grown and carried to maturity with little or no rain. The sparse population formerly grew little but 'dura'; but, about 1850, cotton was introduced and has become the staple crop. Characteristic of both areas is the great variability of the silt-filled flood, both from year to year and even from day to day, which makes control difficult, if not impossible. No serious attempt has yet been made to control the Baraka, while works to control the Gash were commenced in 1923. The water spreads over the delta which, at Kassala, covers more than 360,000 feddans but, to a great extent, floods different areas each year as one or other of the channels silts up. Any tenure system in the generally accepted sense is, consequently, out of the question. Land has been in excess of capacity of the population to cultivate and the population proceeds to the particular flooded area and plants the crop. The conditions have been well described by Cramer Roberts (9). Nevertheless, tribal rights of a somewhat nebulous nature have been established and these have been defined in the case of Kassala by the Gash Delta Lands Proclamation (*Gazette* No. 338) of 1918. Under this Proclamation the land of the Delta is declared to be Government property with full rights of ownership; but certain areas, known as Shaiyotes, are registered in the name of individuals representing sub-tribes or families and these are declared to be held in a fiduciary capacity, namely:—

(1) the land registered may be cultivated annually by the sub-tribe or family during the pleasure of Government,

(2) the registered holder shall allot the land among members of the sub-tribe or family,

(3) the registered holder shall be responsible for the payment of the Ushur tax,

(4) the registered holder is not permitted to take rent,

(5) nothing may be done to interfere with the flow of the Gash in its main channels, while Government retained the right to revoke the allotment or to impose a ground rent on six calendar months' notice. Land not included in the Shaiyotes is directly administered by the Governor of the Province.

In both areas cotton is the main product and the organization of a seed supply and of marketing the crop is directly controlled by Government. In 1923 a concession was granted to the Kassala Cotton Company, a body closely linked with the Sudan Plantations Syndicate, with a view to the development of works partially to control the flood, and Kassala itself was linked up by railway with Port Sudan. The scheme followed closely the lines of the Gezira scheme but the unreliability of the Gash flood and the more nomadic nature of the local population gave rise to certain difficulties. Consequently, in 1927 the concession area was resumed by Government on terms agreed with the Company and the latter received in exchange a concession in the Gezira adjacent to that of the Sudan Plantations Syndicate but with more favourable terms to compensate them for losses in the Gash area.

The whole tendency in the Sudan has, throughout, been for indirect development through agents, and it is of interest to follow the effect of this on that other common activity of Government, the control of cultivation at one or other of its stages. In 1911 was passed the Plant Diseases Ordinance (Ord. 3 of 1911) providing for the prevention of the introduction of insect pests and plant diseases and for the control and eradication of diseases already existing in the country. This is an enabling Ordinance, empowering the Governor General in Council to prohibit or to regulate introduction of plants and to proclaim diseases and areas. It has been sparingly applied. In 1917 the Asal Fly Order was promulgated (*Gazette* No. 313) as applying to Dongola, controlling the dates of planting and of eradication of the crop.

The prosperity of the Sudan is, however, bound up with cotton, for cotton is the exchange culture which dominates all others. Moreover, different varieties characterize the different tracts, Sakel at Kassala, Tokar and the Gezira, and American on the pumping stations and in the southern rains belt. There is, thus, opportunity for adulteration through promiscuous dispersal over and above the common necessity for maintenance of purity within the crop and for the control of disease. This importance of the cotton crop has resulted in special regulations, though power had been taken under the Plant Diseases Ordinance to deal with the cotton worm (*Prodenia litturalis*) and the Mexican Boll Weevil (*Anthonomus grandis*). In 1912 the first Cotton Ordinance (Ord. 4 of 1912) was passed and this, as amended in 1925 (Ord. 6 of 1925) was repealed by the current Ordinance (Ord. 2 of 1926). Under this ginneries are licensed and rules for their working framed. It further gives power to the Governor General in Council to issue Regulations for the purpose of maintaining and improving the quality of cotton as well as for its marketing in the widest sense. The Ordinance was immediately followed by the issue of a complex system of Regulations (*Gazette* No. 471 of 1926) which fall into two sections according as they have general or local application. Among the former are :—

(1) cotton seed from cotton ginned in the Sudan shall only be sown with permit,

(2) cotton seed may be imported only on permit and must be fumigated,

(3) cotton seed kept after the date fixed for the end of the ginning season shall be stored with all openings covered with wire gauze to prevent egress of the pink boll worm moth,

(4) the owner or occupier of cultivated land shall on direction destroy by fire all plants likely to harbour pests on or within 50 m. of his holding,

(5) a date may be notified after which it will be unlawful to irrigate cotton and species of *Hibiscus*.

Among the latter for scheduled areas are :—

Area (*a*)

(6) no cotton seed shall be sown except that supplied under authority,

Area (*b*)

(7) cotton shall be picked clean and all plants are to be destroyed by fire by a prescribed date,

Area (*c*) Berber and Area (*d*) Dongola

(8) only American cotton shall be grown,

(9) all cotton shall be brought to the collecting stations for classification and sale in the controlled markets,

(10) no unginned cotton or cotton seed shall be stored after May 1,

(regulations of a like nature apply to Tokar and the Upper Nile Province)

Area (*e*) Blue Nile Province, specified areas

(11) cotton shall only be grown by or under the supervision of Government or the Syndicate.

Power is further taken to amend the Regulations and to grant exemptions while, under the regulations for ginneries, it is laid down that cotton of different varieties shall be kept and ginned separately, that no cotton ginned or unginned nor seed shall be kept after the close of the ginning season and that no cotton seed shall leave the ginneries other than for export, without a licence.

References.

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(3) C. E. Dawkins; Cd. 8427, *Accts. and Papers*, 1897, 102, p. 587.
(4) Ann. Rept. 1901; Cd. 1012, *Accts. and Papers*, 1902, 130, p. 762.
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(6) Notes on the Gezira Irrigation Project; Jan. 1926.
(7) Land Settlement in the Gezira; H. St. G. Peacock, 1913.
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SOME SWAMP RICE GROWING SOILS OF SIERRA LEONE.

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The area concerned in this paper comprises the estuaries of the rivers, Great and Little Skarcies and Rokel, which flow into the Atlantic on the North Coast of Sierra Leone. Swamp rice has been grown on these estuaries by the natives for about 40 years in increasing quantities up to the present day. The principles of cultivation (1) briefly consist in sowing the rice in nurseries on the uplands during May and June, and transplanting it to the tidal swamps during July and August, six to eight weeks after sowing, at the height of the rains, when the rivers are in flood. The time of transplanting thus depends on the proximity to the sea, and therefore on the salinity of the swamp. At the mouths of the estuaries where salinity is very prevalent, only a short-season rice can be grown, which must be harvested before the end of November, when the rains and fresh flood water have subsided. When the rivers are in flood from July to November, the salt is sufficiently washed out of the top few inches of soil to make rice growing possible. On the grasslands which are subject to flooding only when the rivers overflow, and on the more deeply-flooded inland swamps, rice is usually sown broadcast without the preliminary growth in the nursery. On the tidal areas, usually no cultural operations are carried out, except where the cleared land is covered with weeds which are removed in the dry season by hoeing and cutlassing. No artificial irrigation is practised, but reliance is placed on the flooding of the areas by rivers in the rainy seasons. On the grasslands and inland swamps, the grass is cutlassed in the dry season and burnt *in situ*, and the land is subsequently hoed to a depth of about two to three inches.

The nurseries are prepared in much the same manner as the grasslands, but, when the same land has to be used every year, it is customary to add cut vegetation previous to the burning to ensure a complete "burn". The average yield of husk rice to the area is about 30 bushels (1,500-2,000 lb.) per acre.

Originally, practically all the tidal swamps were covered with Mangroves (Rhizophora). The felling and clearing of these is a tedious operation, and is accomplished as follows. Lanes are cut through the mangrove forest, the trunks being left untouched until all the aerial roots have been cleared. These lanes are cut parallel to each other, and at right angles to the prevailing winds from the west. Felling is begun at the eastern end of the block to be cleared. The sea breeze does not as a rule spring up until after noon. In the morning, the mangrove trunks are cut half way through on the side away from the prevailing breeze. In the afternoon, the cut is completed from the other side. In this way, all the trees are made to fall in the same direction. The Mangrove is felled in the dry season. Occasionally, rice is planted in the second rainy season, and there are instances of its being planted immediately after felling, but usually it is not planted until the third rainy season. Even then the farm will still be littered with the larger stems and roots. For the first year after felling, the Mangrove is left untouched, unless timber is required. In the second dry season, the branches are trimmed off, and either burnt or taken away for fire wood. Some may be carried away during the flood season. The heavier logs are left to rot, which may take many years. Usually, however, the farm is practically clear by the eighth year, although stumps may persist for as long as 20 years.

The rainfall in the area lies between figures (2) (average for 10 years) obtainable from Batkanu (50 to 60 miles inland), and Freetown, which is on the coast to the south. Freetown has a higher rainfall, owing to the mountainous country which rises immediately to landward.

Table I.

	Batkanu.	Freetown.
Jan.	0.03 inches	0.35 inches
Feb.	0.36 ,,	0.26 ,,
March	1.14 ,,	1.15 ,,
April	3.89 ,,	3.59 ,,
May	10.41 ,,	10.75 ,,
June	14.91 ,,	19.80 ,,
July	20.96 ,,	34.51 ,,
August	21.77 ,,	36.19 ,,
Sept.	18.06 ,,	26.90 ,,
Oct.	16.29 ,,	11.86 ,,
Nov.	10.84 ,,	5.58 ,,
Dec.	1.21 ,,	1.53 ,,
Total	119.87 ,,	152.47 ,,

The rivers, in the order from north to south, consist of the Great Skarcies, the Little Skarcies, and the Rokel river, of which latter the Port Loko creek is an important branch. Each of these rivers rises in the mass of Younger Granites which occupies practically the whole of the eastern half of the Protectorate of Sierra Leone, and extends into French Guinea. The three rivers cut across the "Rokel River" Series of Volcanic Rocks, and finally flow over the older and Non-Volcanic Schists and Gneisses, before forming estuaries about 30 miles from the coast. The Great and Little Skarcies join together to form a common estuary some eight to ten miles from the open sea. Of the two, the Little Skarcies carries the larger volume of land-water, and consequently tidal (and salty) conditions exist to an appreciably lesser extent than in the Great Skarcies. The flooding with fresh water is much greater in the

Little Skarcies, and sometimes seriously affects the rice crop through its total submergence. The Rokel river is similar to the Little Skarcies in its volume of land-water, but the Port Loko creek has comparatively little land-water of its own. Tidal conditions and Mangrove vegetation extend all the way to Port Loko (about 25 miles), but the salinity from July to December is not as great as might be expected. The explanation is that the water brought up on the tide is derived from the Rokel river, and, until the estuary of the latter becomes salty, fresh water conditions persist in the Port Loko creek. If it were not for this fresh water derived from the Rokel river, rice could not be grown in the Port Loko creek.

The area around the estuaries is flat, and, in some places natural drainage is bad. The soil examples were taken in the top foot, at those depths at which the profile appeared to change, there being always a marked change at a depth of three to six inches. The second foot was taken complete in nearly every case.

The soils are all alluvial muds, containing up to 90 per cent. of silt and clay, except in a few places, where local vagaries of current have caused thin sandy beds to be deposited. A microscopic examination of the coarse sand particles showed these to consist, for the most part, of quartz grains. In only a few cases were lateritic fragments discovered. The clay fractions of two soils were separated and subjected to analysis by fusion with fusion mixture. The results (Table 2) show that the soils are not lateritic (3), but are similar in composition to many of the alluvial soils to be found inland.

Table 2.

Locality and Sample No.	Mapotolaw. 2833	Kichom 2826
Depth ...	0"–4"	13"–24"
Org. Matter ...	11.81	24.34
Combined Water ...	12.26	
SiO_2 ...	38.98	36.8
Al_2O_3 ...	28.7	24.7
Fe_2O_3 ...	8.0	12.0
Mols SiO_2 / Mols Al_2O_3 ...	2.3	2.5
Type of soil and vegetation.	Sandy, grassland fresh water.	Clay, Mangrove cleared, tidal.

In colour, the soils vary from brown (surface) and yellow (below), to grey (surface) and greyish black (below). The former are characteristic of grasslands, which are only flooded in the height of the rains, and contain comparatively little organic matter. The organic component is typical of those soils on which water remains for some length of time, causing an accumulation of organic matter, and removal or reduction of iron compounds. Particularly is this so with those soils which have been cleared of mangroves, and become inundated with sea water. In general, the soils may be divided into the grassland and fresh water swamps, on the one hand, and the tidal swamps on the other, most of the latter having carried mangrove vegetation at some time or other.

The phosphate and potash contents, both that soluble in Hydrochloric Acid and in one per cent. Citric Acid, were determined in a few selected top soils. The results are set out below (Table 3).

Table 3.

Soil Nos.	Nature.	P_2O_5 HCl sol'ble.	P_2O_5 Citric sol'ble.	K_2O HCl sol'ble.	K_2O Citric sol'ble.
2769	Grassland ...	.093	—	.192	—
2788	Grassland ...	.120	.003	.180	.038
2797	Tidal Swamp ...	.033	.004	.211	.017
2809	Tidal Swamp ...	.159	.002	.289	.068
2821	Tidal Swamp ...	.011	—	.32	—
2833	Grassland Sandy	.020	.002	.070	.008
2838	Tidal Swamp Sandy	.015	.002	.209	—

There is not a great deal to be learnt from these figures. With the exception of soils 2769, 2788 and 2809, the low "total" phosphate content is comparable with that of the sandy and alluvial soils to be found in the interior of the country, but is less than that of the lateritic soils. It is noticeable that the "available" phosphate varies comparatively little in all the soils examined. The potash content, with the exception of soil 2833, is well above the average of that found in the lateritic and non-lateritic soils in the interior (4). The total nitrogen figures vary considerably, but are high in those soils whose organic matter content is great. The organic matter was calculated by multiplying the total carbon content by 1.8, which was determined by a dry combustion method, precautions being taken for the removal of nitrogen and chlorine. The organic matter content varies from less than one per cent. in the lower depths of the grassland soils, to over 25 per cent in the tidal swamps, which formerly carried mangroves. In most of the mangrove soils, especially those on which clearing was effected some time ago, the organic matter shows a definite increase with depth, and the soils themselves contain considerable quantities of partially-decayed mangrove roots.

The grassland soils and those from inland swamps, on the other hand, have a normal diminution of organic matter with depth.

Table 4 shows the variations in nitrogen and organic matter with depth in the two soil types.

Table 4.

TIDAL SWAMP SOILS.

Locality.	Soil Nos.	Depth. inches.	Nitrogen.	Organic Matter	C/N. ratio.
Port Loko	2775	0-1	.36	19.58	29.9
	2776	2-12	.44	20.86	26.07
	2777	13-24	.38	25.4	36.75
Benkia	2778	0-6	.32	10.53	18.09
	2779	7-12	.36	15.98	23.85
	2780	13-20	.34	13.60	21.99
	2781	21-24	.34	20.77	33.59
Kibung	2830	0-3	.25	8.50	18.69
	2831	4-12	.31	8.66	15.36
	2832	13-24	.28	12.89	25.9
Kichom	2824	0-3	.21	6.66	17.44
	2825	4-12	.19	9.66	27.96
	2826	13-24	.18	13.67	41.76
Gbonko-mayira	2785	0-6	.42	16.22	21.25
	2786	7-12	.39	19.48	27.46
	2787	13-24	.33	18.41	30.67
GRASSLAND AND INLAND SWAMP SOILS.					
Mange	2788	0-3	.33	13.61	22.67
	2789	4-12	.15	8.69	31.85
Sirian	2791	0-5	.57	24.11	23.26
	2792	6-12	.09	5.11	31.22
	2793	13-24	.08	4.29	29.48
Kamalo	2794	0-9	.38	8.59	12.43
	2795	10-12	.06	2.00	18.32
Mapoto-law	2833	0-4	.25	4.33	9.52
	2834	5-7	.18	2.16	6.60
	2836	13-20	.04	0.69	9.48
	2837	21-24	.03	1.04	19.05

The usual carbon-nitrogen ratio is about 10 to 12, although in plant residues it is commonly found to lie between 25 and 40 (5). It is noticeable that this ratio is abnormally high in the soils which are inundated with water, and particularly in the tidal swamp soils, it increases with depth. For these soils it is reasonable to suppose that the very high acidity which increases with depth (*see* below), the excessive salt content and the lack of aeration have considerably inhibited the normal processes of decomposition. As stated above, masses of mangrove roots, still exhibiting some structure, may be observed in the lower depths of those soils which have been cleared of mangroves 20 or more years ago.

The following figures (Table 5) show the effect on the organic matter content, &c., produced by burning the soil. The soils were taken from a rice nursery at Katakera to a depth of three inches before and after burning.

Table 5.

Soil Nos.	Nitrogen.	Organic Matter.	C/N. ratio.
2842 before burning	.26	19.63	41.52
2843 after burning	.08	2.06	14.16

Humus determinations, made by extracting the soil with four per cent. ammonia solution, were carried out on a certain number of soils. On the whole, about 50 per cent. of the organic matter gave rise to humus irrespective of the depth at which it occurred.

The pH determinations were made colorimetrically on a 1 : 1 soil : water suspension, using a B.D.H. capillator with different indicators. This method possibly does not give strictly accurate results, but the figures may satisfactorily be used for comparison. The grassland soils show a pH value of 4.0 to 4.5, usually, though not always increasing with depth as the organic matter decreases. The soil from Mapotolaw (Table 6), is an example of this.

Table 6.

Soil Nos.	Depth. Inches.	Organic Matter.	pH. Value.
2833	0-4	4.33	4.4
2834	5-7	2.16	5.6
2835	8-12	N.D.*	6.3
2836	12-20	0.69	6.9
2837	20-24	1.04	7.2

* N.D.—not determined.

The inland swamp soil from Sirian gave somewhat lower pH figures.

Soil Nos.	Depth. Inches.	Organic Matter.	pH. Value.
2791	0-5	24.11	3.6
2792	6-12	5.11	3.6
2793	13-24	4.29	3.7

The tidal swamp soils, which formerly carried mangroves, show an extremely high acidity with a pH value of less than 3.0 in many instances. It was also noticeable that, where the soil had been under cultivation for some time, and had been cleared of mangroves for 30 years or more, this high acidity did not occur in the top three to six inches, although it persisted below that depth. It is reasonable to suppose that intense acidity is caused by the action of soluble chlorides

contained in sea-water, on the organic acid complex resulting from the partial decay of mangrove roots, this action probably resulting in the liberation of free hydrochloric acid.

$$(H + \text{organic-complex}) + Na' + Cl'$$
$$= (Na - \text{organic complex}) + H' + Cl'.$$

The soils themselves effervesce when solutions of carbonates or moist calcium carbonate are added to them. One soil was placed in a retort and moistened, and the retort then heated on a water bath, the evaporate being passed into water.

The resulting solution was found to be acidic, and to contain chlorides. When such a soil was shaken with water for a few minutes, and the mixture filtered, the filtrate was found completely to redden methyl orange. As will be pointed out later, the soluble salt content of the top three to six inches of these soils varies considerably in the wet and dry seasons, whereas little such variation occurs at depths below one foot. Consequently, during the rainy period when most flooding with fresh water occurs, there is probably a gradual removal of soluble acids, and, as time goes on, the acid humus complex becomes "sodium saturated", and at the same time may have more tendency to become oxidised. The result is that the top few inches become less and less acidic, and usually contain less organic matter, while the lower depths, which are not so much subject to this washing, retain their acidity. In one seasonal variation no appreciable change in pH value is noticeable, but the fact that it probably does occur over a length of time, may be seen from the following figures.

Table 7.

SOILS RECENTLY CLEARED OF MANGROVE.

Locality.	Sample Nos.	Depth. Inches.	pH Value.	Organic Matter.
Makoya ...	2782	0-3	2.2	29.29
	2783	4-12	2.3	18.97
	2784	13-24	3.2	N.D.
Mambolo ...	2821	0-3	3.1	26.08
	2822	4-12	2.6	25.34
	2823	13-24	2.7	N.D.
SOILS UNDER CULTIVATION FOR 20-30 YEARS.				
Benkia ...	2778	**0-6**	**6.5**	10.53
	2779	7-12	3.0	15.98
	2780	13-20	3.4	13.60
	2781	20-24	2.6	20.77
Ropoint ...	2806	**0-3**	**6.7**	9.35
	2807	4-12	4.4	6.54
	2808	13-24	3.1	N.D.
Kibung ...	2830	**0-3**	**6.9**	8.50
	2831	4-12	3.8	8.66
	2832	13-24	3.3	12.89

Table 7.—(CONTINUED.)

Soils under Cultivation for 20-30 years.—(*Continued*).

Locality.	Sampe Nos.	Depth. Inches.	pH Value.	Organic Matter.
Tumbu	2800	**0-3**	**6.7**	11.5
	2801	4-12	3.0	15.39
	2802	12-24	3.2	N.D.
Kichom	2824	**0-3**	**6.5**	6.66
	2825	4-12	2.7	9.66
	2826	13-24	2.6	13.67

On all these soils, rice was growing quite well, even on the recently-cleared Makoya and Mambolo soils, and though it is unusual for rice to be transplanted on a recently cleared soil, any effect on growth is apparently more likely to be due to physical causes, arising through super-abundance of mangrove roots, rather than to intense acidity. Soils having a pH value of under 4 or over 9, are generally regarded as unsuitable for cultivation, and Arrhenius (6) states that, beyond these limits, growth is inhibited, so that only a few species of plants are able to grow without being severely injured. It is reasonable to predict that, with the gradual removal of soluble acids and oxidation of organic matter, the top three to six inches of these soils will become less and less acidic, due to the complete formation of a sodium-clay.

A further effect of acidity is exhibited by the formation of water-soluble ferrous iron. This, as a rule, does not occur on those soils where the pH value is higher than 3.4, and consequently, is not often found in the top soils (except soils 2782 and 2821). The formation of water-soluble ferrous salts is probably due to the "active" acid bringing ferric iron into solution, which is then reduced by the organic matter to the ferrous state (7).

The total water-soluble iron was determined in two soils, giving the figures 1.064 per cent. and 0.532 per cent., the pH value of the soils being 2.8 and 3.0 respectively. Ferrous salts are generally regarded as toxic to plant-growth (8), and it is interesting to observe that this toxicity does not appear to apply to swamp rice.

Lime requirement determinations were carried out on most of the soils by the method of Hutchinson and MacLennen (9). In many cases, the corked bottles containing the soil and calcium bicarbonate burst, owing to pressure of the generated carbon dioxide. Frequently, the filtrate was found to be completely acidic to methyl red indicator before the titrating acid was added, and the experiment had to be repeated, using smaller quantities of soil, ten or sometimes five grammes of soil to 200 c.c of $\frac{1}{50}$ normal calcium bicarbonate solution, instead of the customary 20 grammes of soil. In such soils, the lime requirement figure is extremely high, and seems

to be correlated with a high organic matter content an a low pH value, as the following figures indicate.

Table 8.

Soil Nos.	Lime Requirements ; gms. $CaCO_3$ per 100 gms. soil.	pH Value.	Organic Matter %
2764	2.12	2.4	18.57
2781	3.72	2.6	20.77
2783	3.76	2.3	18.97
2801	1.04	3.0	15.39
2810	3.16	2.5	17.69
2815	1.00	3.1	28.94
2820	1.88	3.0	26.12
2821	1.56	3.1	26.08
2822	1.75	2.6	25.34

The only two soils collected from the top three to six inches layer in this table are Nos. 2815 and 2821. The former has never been cultivated for rice, although wild rice grows well on it. The latter has been recently cleared of mangroves, and carries heavy crops of a short-season rice, all the rice stalks which remain after harvest becoming rotted by sea water.

The soluble chlorides were determined in every soil sample by shaking ten grammes of soil with 50 c.c. of water and leaving the suspension overnight. The mixture was then filtered, and the chlorides determined by titration of an aliquot of the filtrate with N/10 silver nitrate solution. The results are expressed as sodium chloride per 100 grammes of soil. In many cases, the filtrates were acidic, and contained ferrous salts, which had to be removed before proceeding. The results show that the salt content (particularly

Table 9.

Locality.	Sample Nos.		Depth. inches.	pH		Lime Requirement.		Soluble Salts.	
	Rains.	Dries.		Rains.	Dries.	Rains.	Dries.	Rains.	Dries.
Bumbe	2907	2812	0-5	4.4	—	0.79	—	0.289	1.189
	2908	2813	6-12	4.5	4.3	0.58	0.66	0.376	0.717
	2909	2814	13-24	5.7	5.7	0.40	0.56	0.477	0.526
Gbonkomaria	2910	2815	0-4	3.5	3.1	0.89	1.0	0.289	1.821*
	2911	2816	5-12	3.4	3.4	0.86	0.9	0.470	0.532
	2912	2817	13-24	3.0	3.2	0.80	0.80	2.081*	0.654*
Mambolo....	2913	2821	0-3	2.2	3.1	1.80	1.56	0.636*	1.85*
	2914	2822	4-12	2.5	2.6	1.82	1.76	1.098*	1.532*
	2915	2823	13-24	2.7	2.7	1.66	1.83	1.127*	1.619*
Kichom	2916	2824	0-3	6.4	6.5	0.42	0.38	0.419	1.315
	2917	2825	4-12	2.3	2.7	0.93	0.93	1.329*	1.792*
	2918	2826	13-24	3.1	2.9	0.94	0.95	1.329*	1.734*
Kibung	2919	2830	0-3	6.5	6.9	0.31	0.24	0.332	1.341
	2920	2831	4-12	3.6	3.8	0.90	0.75	0.622	2.232
	2921	2832	13-24	3.2	3.3	0.83	0.90	1.734*	1.966*
Makumpan	2922	2827	0-6	6.0	6.3	0.34	0.28	0.491	1.445
	2923	2828	7-12	6.1	5.7	0.37	0.35	0.679	1.804
	2924	2929	13-24	5.4	5.6	0.49	0.38	1.351	1.908
Ropoint	2925	2806	0-3	6.7	6.7	0.12	0.3	1.278	3.353
	2926	2807	4-12	6.4	6.5	0.12	0.4	1.647	2.312
	2927	2808	13-24	4.4	3.1	0.48	0.9	2.746	2.602*
Tumbu	2928	2800	0-3	6.7	6.7	0.25	0.58	0.267	1.376
	2929	2801	4-12	3.0	3.0	0.85	1.04	0.708*	0.752*
	2930	2802	13-24	3.4	3.2	0.45	0.99	0.954*	0.636*
Gbonkomayira	2931	2785	0-6	6.1	6.1	0.41	—	0.173	1.029
	2932	2786	7-12	3.5	3.3	0.79	0.80	0.405*	0.809*
	2933	2787	13-24	3.0	2.8	0.90	0.80	0.752*	0.773*
Makoya	2934	2782	0-3	2.2	2.2	—	—	0.332*	1.041*
	2935	2783	4-12	2.3	2.3	3.68	3.76	0.52	0.752*
	2936	2784	13-24	3.1	3.2	—	1.84	0.867*	0.694*
Benkia	2937	2778	0-6	6.7	6.5	0.44	0.28	0.145	0.578
	2938	2779	7-12	2.8	3.0	0.92	0.99	0.405*	0.578*
	2939	2781	13-24	2.4	2.6	0.92	0.81	0.578*	0.520*

* contains iron in solution.

in the top three inches) is very high, often being over one per cent. in the soils of the tidal swamps. There is always an appreciable amount of chloride on the inland swamps and grasslands. Since the soil samples had been taken in the driest time of the year, when there is no flooding with fresh water, and the rice is all off the land, a fresh collection of samples of the more salty soils was obtained from the same places and at the same depth, sampling being performed towards the end of the rains, when the rivers were in flood and the rice not yet harvested. In every case, the rice was growing well, except in the case of soils 2815 and 2910, 2816 and 2911, and 2817 and 2912 (different depths of the same soil from Gbonkomaria), on which it has never been grown. The results are shown in (Table 9). Where possible, pH values and lime requirements have been determined in addition.

It is very noticeable that the salt content drops to an extent of 60 to 80 per cent. in the top three inches to six inches. In the next six inches to nine inches, the drop is less, *i.e.* about 10 to 30 per cent., whereas below one foot, the drop is purely nominal. In some of the 2nd-foot depths, there is a distinct gain in salt content, which requires explanation. Soils 2817 and 2912 (13 inches to 24 inches) have a salt content of 0.654 in the dries, and 2.081 in the rains respectively. This soil lies in a depression, back from the river, and is very badly drained. It is probable that the salt is washed down rather than washed away during the flooding with fresh water. Soil 2927 (13 inches to 24 inches) shows a slight increase in salt content during the rains over soil 2808 in the dries, the same increase is found with soil 2930 over soil 2802, and with soil 2936 over soil 2784. All these soils occur at the mouths of the estuaries, and are very low-lying; increase in salt content is again probably due to bad drainage.

In spite of the drop in salt content during the rice-growing seasons, the top soils contain more salt than is ordinarily associated with fertility, although it must be remembered that, being continually flushed with fresh water, the soil-solution is not as concentrated as it would appear to be from these figures, which were obtained by examining air-dried soils. That the salt is rapidly removed in solution from the soil can be seen from the following experiment. Ten grammes of soil 2827, containing 1.445 per cent. of sodium chloride were repeatedly leached on a filter with successive quantities of 50 c.c. of distilled water. The results obtained are presented in Table 10.

Table 10.

1st	50 c.c.	84 per cent. of chlorides removed.
2nd	50 c.c.	12.5 do. do. do.
3rd	50 c.c.	3 do. do. do.
4th	50 c.c.	Trace

Summary.

1. A description is given of swamp-rice cultivation, rainfall, geology and topography of a district of Sierra Leone.

2. Clay fractions of two selected soils were separated and analysed. They were found not to be lateritic.

3. The soils are mostly silty-clays, and are divided into (A), grasslands, flooded with fresh water only at the height of the rains, and inland swamps, covered with fresh water during most of the rains and (B), tidal swamps which formerly carried mangrove vegetation, and whose water is brackish or salty during most of the year. The soils were sampled at depths corresponding to changes in the appearance of the profile.

4. Total and available phosphate and potash determinations were made on selected soils. Total phosphate figures vary irrespective of the nature of the soil but little variation occurs in the available phosphate content. The potash content is higher than that found in soils of the interior of the country.

5. Nitrogen content varies, on the whole, with organic matter content.

6. Organic matter was calculated from total carbon figures, and is high in the case of the tidal swamps, and tends to increase with depth. In the grassland soils, it is lower, and tends to decrease with depth. A few humus determinations showed that about 50 per cent. of the organic matter is soluble in alkali.

7. The carbon-nitrogen ratio increases with depth in nearly every case, and is distinctly higher than normal (10-12), especially in the tidal swamps. The effect of burning is to lower the carbon-nitrogen ratio.

8. The pH figure varies with the type of swamp, and with depth. For grasslands soils, it varies from about pH 4 to about pH 7, increasing with depth. Inland swamps give rather higher figures. The tidal-swamp soils show a pH value of less than 3 in many cases, at all depths on soils recently cleared of mangroves. Where clearing had been undertaken many years ago, the pH value of the top three to six inches of soil has increased to over pH6, although below this depth, the original intense acidity prevails.

9. The intense acidity is probably due to the action of sodium chloride, present in sea-water, on the decaying mangrove roots, possibly producing free hydrochloric acid. Frequent flushing with fresh water would tend to remove the acid and to raise the pH value. The soils themselves decompose carbonates when moist.

10. Soils with a pH value of less than 3.5, contain appreciable quantities of soluble ferrous salts.

11. Very high lime requirement figures were obtained for the tidal swamp soils, where the pH value was low, and the organic matter high.

12. All the soils, both grasslands and tidal swamps soils, contain soluble chlorides. The tidal swamps samples, taken in the dries, contained up to three per cent. (reckoned as sodium chloride). Samples of the more salty soils, taken in the height of the rains, showed a reduction in salt content of 60 to 80 per cent. in the top three to six inches, 10 to 30 per cent. in the next six to nine inches, and little or no decrease in the second foot. Badly-drained soils show an increase in salt content in the second foot. Experiments demonstrated that the salt could easily be washed out of the soils.

13. Rice appears to give satisfactory growth on all the soils in which it had been transplanted, even where acidity and soluble chlorides and ferrous salts were abundant.

The authors wish to thank the Sierra Leone Government for permission to make use of the material in this paper.

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COTTON NOTES.

Cotton Hybridization Experiments.

Trinidad Red Kidney × *Sea Island*.

As a result of genetic studies by Dr. S. C. Harland it has been found that the character Red Leaf, Weak, Petal Spot of the perennial Peruvian type Trinidad Red Kidney is allelomorphic to the character Green Plant Body, Strong Petal Spot. If red is transferred to a Sea Island plant body, it will be possible to distinguish any natural crosses in the commercial crop, since all plants with either a green plant body or strong petal spot are rogues. By repeated back-crossing the production of a Superfine Sea Island strain, pure for red plant body and weak petal spot, has been accomplished. Six selections have been made, with mean maximum lint lengths varying from 53.8 mm. to 58.2 mm., for further purification of staple length next season.—(*St. Vincent Cotton Experiment Station Report*, 1931-32. Empire Cotton Growing Corporation, 1933).

* * *

Acclimatization of Cottons.

In a paper by Dr. S. C. Harland published in the *Empire Cotton Growing Review* (IX) reference is made to the difference between the wild and cultivated cottons, in respect of those characters which make for yield and quality of lint, all of which differences are the result of selection in the past. Hence in introduction, the background against which the type under consideration was selected, must be borne in mind. Repeated selection in a given district leads to the gradual discarding of all genes but those which make for success in that district and the very genes discarded are often those which would make for success in a different district. Interesting examples are given of cases in which all introductions of modern highly-bred cottons of a particular type have failed, whereas more primitive cottons of this type have succeeded.

The necessary variation in genes can be obtained by using a wild type of its hybrids for selection. The method recommended is to make a large mixed F_4 population by selfing a large number of the best F_2 and F_3 plants or repeating this process even further. A similar method is advocated also when crossing two well-adapted cottons possessing characters which it is desired to combine. Here the method of back-crossing to one of the parents is often preferable to selfing. Suitable wild parents for different purposes are suggested.—(*Plant Breeding Abstracts*, Vol. III, No. 2.)

* * *

Detecting Pink Bollworms.

It has been found possible by means of X-ray photographs to detect living and dead larvae of *Platyedra* (*Pectinophora*) *gossypiella*, Saund. (pink bollworm) in cotton seeds. Seed direct from the gin can be used with as good results as seed from which the lint has been removed, but unginned seed is rather less satisfactory as it occupies too much room on the film and the seeds are often super-imposed so that it is impossible to obtain a clear picture of all of them. The seeds are best arranged touching in closely packed rows of one layer over the film. This operation is, however, too expensive for regular use.—(*Review of Applied Entomology*, Vol. XXI, Series A, Part 1).

THE COMPOSITION OF, AND NUTRIENT UPTAKE BY THE BANANA PLANT, WITH SPECIAL REFERENCE TO THE CANARIES.

By A. F. Baillon, E. Holmes and A. H. Lewis.

Introduction.

The conduct of properly-replicated fertilizer plot trials in the Canaries is so complicated by great variations in soil types, even in restricted areas, and by the relatively enormous differences in the growing period of different specimens of the same variety of banana, that the value of any experimental results which may be obtained is problematical. As a consequence, the experiment described in this paper was devised to determine the amounts of plant food removed from the soil by one Cavendish plant from the time of planting the head to the time of cutting the bunch for shipment. This has an obvious bearing on the study of manurial practice for bananas in the Canaries.

It is, of course, well known that chemical analysis of a crop is by no means a sufficient guide to the manurial needs of that crop; taken by itself it may indeed be positively misleading. The supply of available plant nutrients in the soil is dependent on many other factors as well as that of actual uptake by the plant; moreover, plant nutrients may exert their effect on growth in various indirect ways in addition to those directly associated with the amounts in which they are taken up by the plant. Nevertheless, a knowledge of the amounts of plant nutrients actually removed from the soil by a crop is of value, along with a consideration of the other factors involved, in studying the manurial needs of that crop. The data reported in this paper are presented in relation to the manurial needs of bananas in the Canaries, strictly in accordance with the above considerations. They are also of some value as supplementing the scanty information available in the literature with regard to the composition of the banana plant as a whole, and of its constituent parts.

Experimental.

The experiment was conducted on the Miramar Farm of Messrs. Fyffes Ltd. in the famous Oratava Valley of Teneriffe. A pit was formed by removing the soil in the corner of a terrace from an area of four yards square down to the rock which was swept clean. The rock and cement walls of the terrace formed two sides of the pit and the remaining sides, from the parent rock to a level of about one foot above the surrounding land, were formed by a plastered brick-on-edge wall. The volume of the pit up to the level of the surrounding land was 96.7 cubic feet.

The pit was filled to the level of the surrounding land with soil, previously unplanted to bananas, brought from the Matanza district. The weight of soil in the pit was 3267 kg. A sample of the soil was sent, in a sealed tin-lined case, to Jealott's Hill Agricultural Research Station, England, for analysis.

From six banana heads with small suckers attached and of as uniform size, weight and appearance as possible, one was selected to be planted in the pit and another was despatched on 11th September, 1929, in a sealed tin-lined case to England for analysis, where it arrived in good condition on 27th September.

The head was planted according to local practice on 11th September and was irrigated throughout the growing period every fifteen days except when rain fell. The irrigation water used was led direct from a gallery through a pipe to the pit so that no contamination from other manured areas occurred. A wind-break (8 by 8 yards) was erected on two sides of the pit, the permanent walls of the terrace serving for the purpose on the other two sides. All fallen leaves, trash and unnecessary suckers were hoed into the soil.

A fertilizer mixture, 1½ lb. for each application, composed of ammonium sulphate, superphosphate, potassium sulphate and ferrous sulphate and having an analysis of 10.59 per cent. N, 2.97 per cent. P_2O_5 and 13.34 per cent. K_2O, was applied on 4th April, 25th June and 26th September, 1930, the soil being irrigated one day after the fertilizers had been applied. Although this practice of watering soon after applying fertilizers may lead to relatively large losses of plant nutrients, it was used in the experiment as it is the standard practice in the Canaries. The reason for watering after instead of before applying the fertilizers is that the soil becomes so wet after watering that it is difficult to apply the fertilizers and the soil may become badly puddled by treading.

The bunch was born on 15th September, 1930. The mature bunch (13 hands) was cut on 23rd March, 1931, and was prepared for shipment in the usual commercial manner. The whole plant, including the stump, roots and a little adhering soil, was dug up and despatched in a sealed, tin-lined case to England on 25th March, 1931, where it arrived in good condition on 11th April. After thorough mixing, a representative sample of soil was taken from the pit on 23rd March and was also desptached to England in a sealed, tin-lined case.

Results.

In order to obtain a measure of the uptake of nitrogen, phosphoric acid and potash by the plant, the amounts of these materials in the head and in the mature plant were determined. The mature plant was divided into twelve parts which were analysed separately for nitrogen, phosphoric acid and potash and also for lime, magnesia and iron (ferric) oxide. The preliminary and final soil samples were also analysed.

The full analytical results are given in Tables I-III.

TABLE I.

Banana Head.

Weight of head .. .. ..39.18 kg.
% dry matter in head. 15.58
Weight of dry matter in head .. 6.16 kg.

	Per cent. of Dry Matter	Total wt. in head. gm.
Nitrogen (N) ..	1.05	64.19
Phosphate (P_2O_5)	.39	23.73
Potash (K_2O) ..	2.89	176.56

Discussion of Results.

Composition of Banana Plant.

The weights of potash in both the head and the mature plant were high, the phosphate low and the nitrogen moderate. From Table II, it will be seen that the fruit stalk was very high

TABLE III.

Soil.

Weight of moist soil and stones in pit..32.67 kg.
Weight of oven dried soil (excluding stones) in pit .. .. ..25.61 kg.

	Before Experiment. Original sample.		After Experiment. Final sample.	
	% of oven dried soil*.	Total wt. in pit.	% of oven dried soil*.	Total wt. in pit.
	%	gm.	%	gm.
Nitrogen (N)	.230	5890	.225	5762
Phosphate (P_2O_5)	.161	4123	.152	3867
Potash (K_2O)	.782	20001	.497	12728

* Excluding stones.

TABLE II.

Mature Plant.

WEIGHT OF MOIST MATURE PLANT—117.79 KG.

Part of Plant.	Dry Matter %	Weight of Dry Matter gm.	Nitrogen (N)		Phosphate (P_2O_5)		Potash (K_2O)		Lime (CaO)		Magnesia (MgO)		Iron Oxide (Fe_2O_3)	
			% of D.M.	Total Weight gm.	% of D.M.	Total Weight gm.	% of D.M.	Total Weight gm.	% of D.M.	Total Weight gm.	% of D.M.	Total Weight gm.	% of D.M.	Total Weight gm.
Main stem	8.6	4,200	1.07	44.94	0.28	11.76	8.24	346.08	2.09	87.78	0.99	41.58	1.57	65.94
Main root ..	16.2	4,145	1.04	43.11	0.22	9.12	4.12	170.77	0.63	26.11	0.69	28.60	1.61	66.73
Main small roots	17.4	497	0.90	4.47	0.12	0.60	2.10	10.44	0.99	4.92	0.69	3.43	1.94	9.64
Main leaf stems	14.9	596	1.03	6.14	0.28	1.67	4.20	25.03	3.99	23.78	0.91	5.42	0.65	3.88
Main leaves	42.2	1,532	2.24	34.32	0.38	5.82	2.93	44.89	2.22	34.01	.72	11.03	0.24	3.68
Fruit ..	16.9	4,710	1.02	48.04	0.27	12.72	3.57	168.15	0.15	7.07	0.26	12.25	0.0	0.0
Fruit stem	5.3	240	1.28	3.07	0.86	2.06	14.28	34.27	0.61	1.46	0.75	1.80	0.86	2.06
Male flower	10.6	120	1.98	2.38	0.65	0.78	7.93	9.52	0.86	1.03	0.36	0.43	1.73	2.08
Sucker root	7.3	1,078	1.26	13.58	0.22	2.37	6.85	73.84	0.76	8.19	1.05	11.32	1.98	21.34
Sucker stem	7.2	965	1.84	17.76	0.45	4.34	8.95	86.37	0.73	7.04	0.67	6.47	0.70	6.76
Sucker leaf stem	12.5	84	1.60	1.34	0.41	0.34	7.51	6.31	0.91	0.76	0.75	0.63	0.28	0.24
Sucker leaves	39.0	128	1.65	2.11	0.53	0.68	4.72	6.04	1.04	1.33	0.98	1.25	0.48	0.61
TOTAL WEIGHT IN PLANT	—	18,295	—	221.26	—	52.26	—	981.71	—	203.48	—	124.21	—	182.96

in percentage potash content, and was also relatively high in percentage phosphate content The fruit was noticeably low in percentage lime, magnesia and iron contents. Most of the lime was situated in the roots, stem and leaves, and most of the magnesia and iron in the roots and stem.

There appears to be very little data in the literature on the chemical composition of the banana plant, although the flesh of the fruit and the fruit stem have been studied, the former owing to its importance as food, and the latter in connection with the search for possible sources of potash during the late War. In the pit experiment under consideration, the flesh of the fruit was not analysed separately, being included with the skin, so that no comparison is possible with figures quoted in the literature for the flesh. A comparison of the figures obtained for the fruit stalk in the experiment here described with those of certain other authors is given below.

Fruit Stalk.

Per cent. of Dry Matter.

	N.	P_2O_5.	K_2O.	CaO.	MgO.	Fe_2O_3.
Present Experiment ..	1.28	.86	14.28	.61	.75	.86
Billings & Christie[1] ..	.46	.44	10.83	.71*	.42*	—
Ellis[2] ..	—	.82	13.73	.51	.50	.05
Hanley[3] ..	—	—	12.35	—	—	—
Ruschmann[4] ..	.86	.44	12.82	—	—	—

* Determinations on water extract of ash.

The above figures show considerable variation in chemical composition between different fruit stalks, but the very high potash content is common to all. It would appear improbable that the difference between the ferric oxide content given by Ellis and that found in the stalk of the plant from the Canaries' pit experiment was due to the plants being inherently widely different in chemical composition since the content of the other mineral constituents was very similar in both stalks. The fact that ferrous sulphate was contained in the fertilizer used in the pit experiment, coupled with a high iron content of the Matanza soil in which the plant was grown, appears to be a much more likely cause of the higher iron content of the stalk from the plant grown in the pit.

Plant Food Uptake by the Banana.

Assuming that the original head from which the mature plant developed, and the other head which was analysed, were directly comparable (*i.e.*, assuming that there was no important variation in weight and composition between the two heads, so that the head analysed and that planted were practically identical in all respects), the amounts of plant food absorbed by the plant during growth from the head to the mature stage may be calculated as follows:—

	Grams.		
	N.	P_2O_5.	K_2O.
Head	64.19	23.73	176.56
Mature Plant ..	221.26	52.26	981.71
Uptake by Plant ..	157.07	28.53	805.15

The above figures indicate that the plant absorbed a moderate amount of nitrogen, relatively little phosphate and a very large amount of potash.

As a check on the above method of calculation of the uptake of nutrients by the plant, the plant food content of that part of the mature plant corresponding to the head from which a fresh plant would be grown, was calculated. The head consists of about one-half of the whole root (or one-half of the main root + one-half of the sucker root) and one-third of the main stem. The amounts of nutrients so estimated are as follows:—

	Grams.		
	N.	P_2O_5.	K_2O.
½ main root ..	21.56	4.56	85.39
½ main small roots ..	2.24	0.30	5.22
½ sucker root ..	6.79	1.19	36.92
⅓ main stem ..	14.98	3.92	115.36
	45.57	9.97	242.89

The above figures are of the same order of magnitude as those for the original head analysed (64.19 gm. N, 23.73 gm. P_2O_5 and 176.56 gm. K_2O) but the amounts of N and P_2O_5 are lower and the K_2O higher in the former.

The uptake of nutrients calculated as before, but using these values for the estimated head is:—

	Grams.		
	N.	P_2O_5.	K_2O.
Mature Plant ..	221.26	52.26	981.71
Estimated Head ..	45.57	9.97	242.89
Uptake by Plant ..	175.69	42.29	738.82
do. do. (Direct estimate P.5)	157.07	28.53	805.15

Part of the difference between the estimates of the uptake of N and P_2O_5 may be due to the fact that nutrients were translocated from the original head to the main plant. Such a translocation cannot, however, account for the amount of K_2O being higher in the estimated head than in the original head.

The results show that, as would be expected, there may be an appreciable variation between apparently similar plants. The present authors suggest that there may be some relation between the variation in chemical composition of the heads and the great variation known to occur in the time required for the plants to reach maturity (5). In view of the variation in chemical composition of the two different heads, the average uptake of nutrients by the banana plant from this experiment has been obtained by taking the mean of the two sets of figures given above :—

Mean Uptake of Nutrients.

Grams.		
N.	P_2O_5.	K_2O.
166.38	35.41	772.0

Net Removal of Plant Food from the Soil.

One important practical application of the results of this investigation is in the calculation of the net amounts of nutrients actually removed from the land in the form of plant material. The only parts of the plant not subsequently chopped up and hoed into the soil are the fruit and the fruit stem, the leaves and two-thirds of the main stem. The amounts of nutrients in these parts are given below.

	Grams.		
	N.	P_2O_5.	K_2O.
Fruit	48.04	12.72	168.15
Fruit stem ..	3.07	2.06	34.27
⅔ main stem ..	29.96	7.84	230.72
Leaves	6.14	1.67	25.03
Leaf stem.. ..	34.32	5.82	44.89
	121.53	30.11	503.06

The above figures represent the actual amounts of nutrients which would have been *permanently removed from the land* by this banana plant if it had been grown and harvested in the ordinary way.

Fertilizer Requirements.

The figures for the uptake of nutrients by the banana plant during growth from the head to the mature stage and the estimated net removal in the fruit, stem and leaves, both give, therefore, the same indications, viz., that a fertilizer mixture considered solely for the purpose of supplying the nutrient elements taken up by the plant and for replenishing the actual exhaustion of the soil by the plant (disregarding, for the moment, the question of variation between soils) should be moderate in nitrogen, low in phosphate and high in potash content. The ratio of nutrients in the estimated uptakes and net removal from the soil are :—

	N.	P_2O_5.	K_2O.
Original head to mature plant ..	5	1	25
Estimated head to mature plant	4½	1	24
Net removal (fruit, ⅓ stem, &c.)	4	1	17

In view of the inherently very high available potash content of the soil used, the complete fertilizer used, which supplied 216.6 gm. N, 60.62 gm. P_2O_5 and 272.3 gm. K_2O per stool and had an N : P_2O_5 : K_2O ratio of 3½ : 1 : 4½ appears very suitable for supplying the relative amounts of these nutrients which are taken up by bananas in the Canaries. On soils, such as the Matanza soil under examination, in which the potash content is very high, less potash might suffice but even this soil would probably need relatively large amounts of potash fertilizers after it had been under cultivation for two or three years.

The low phosphate-content of the fertilizers used generally in the Canaries has hitherto been justified on the grounds that the Cavendish bananas are very closely planted on shallow soils, with the result that root development needs little extra encouragement. It is certainly true that the soils throughout the plantations are one network of fibrous banana roots.

Plant Food Balance Sheet in the Soil.

Since the amounts of nutrients supplied by the fertilizers, the uptake of nutrients by the plant and the amounts in the soil before and after the experiment are all known, it is possible to calculate a plant food balance sheet for the soil.

	Grams.		
	Nitrogen N.	Phosphoric Acid P_2O_5.	Potash K_2O.
Soil at commencement ..	5890	4123	20001
Add : Fertilizers used ..	216	61	272
	6106	4184	20273
Subtract : Soil after growth of banana plant ..	5762	3867	12728
Equals : Total loss of plant food	344	317	7545
Subtract : Plant food uptake by banana plant ..	166	35	773
Equals : Plant food lost from soil by other means, *i.e., Dead loss* ..	178	282	6773

The loss of nitrogen is not surprising, and the loss of phosphoric acid, though appreciable, is not excessive. The loss of potash is, however,

remarkably high. The soil consists of comparatively young unweathered volcanic material abnormally high in total and "available" potash* and it is probable that the relatively high average temperature in the Canaries and the copious irrigation favour a rapid breakdown of the soil with the liberation of much potash in a form capable of washing out in the drainage water.

In order to study this point, the loss of potash from this soil, by leaching with an aqueous solution of carbon dioxide, was determined in the laboratory. For comparative purposes the loss from a British soil, known to be relatively well supplied with potash, was also studied†.

The potash in the leachings was determined with the results given below.

Potash in Leachings.

Per cent. of Air Dried Soil.

	"Total" K_2O in Soil. ‡	*"Available" * K_2O in Soil.*	*K_2O in Leachings.*
Canaries' Soil	.452	.068	.0094
Jealott's Hill Soil ..	.531	.019	.0014

The loss of potash by leaching from the Canaries' soil was very high, being about seven times that from the Jealott's Hill soil. This result supports the view that the very high loss of potash from the soil noted in the pit experiment was due to the leaching out of potash liberated from the soil in a soluble form by the rapid weathering of the volcanic material of which it is composed under the influence of the high temperatures and plentiful water supply.

Further work is in progress on this problem.

Conclusions.

(1) In so far as it is one of the functions of a fertilizer to supply N, P_2O_5 and K_2O in relative amounts corresponding to their uptake by the crop, and to replenish the losses, from the soil, of these plant nutrients in that part of the crop which is permanently removed from the land, the fertilizer mixtures used for bananas in the Canaries should be high in N and K_2O. The mixtures at present in use (5), arrived at by empirical methods, conform satisfactorily to this requirement.

(2) The Canaries' soil used in the experiment described was well supplied with potash, which was in a very readily soluble form. Although this probably means that when virgin soils in the Canaries are first brought into cultivation, use of potassic artificials is not so important, the very fact that the plentiful reserves of potash are readily soluble and available probably results in a very rapid depletion of these reserves, and big losses of potash from the soil in the drainage water; so that after a few years' cultivation, quite apart from the uptake by the plant, which is here a minor source of soil exhaustion of potash, the soil is likely to be short of available potash and crops, especially potash loving crops such as the banana, will need a liberal amount of potash in the fertilizer mixture used. The more readily soluble and available the potash reserves of the virgin soil, the more rapidly is the soil likely to become potash deficient when it is brought under irrigation. Such rapid exhaustion of potash is exceptional and probably occurs chiefly with young volcanic soils.

Rapid depletion of nitrogen reserves is of more general occurrence, being less dependent on the geological origin of the soil, and primarily a necessary consequence of cultivating soils with irrigation under sub-tropical or tropical conditions. Hence it is not surprising that in addition to high potash, high nitrogen is used in banana fertilizers in the Canaries.

Summary.

(1) A Cavendish banana plant was grown in a special pit on the Miramar Farm in the Oratava valley of Teneriffe.

(2) From chemical analysis of a "head" similar to that from which the experimental plant was grown, and of the whole of the latter at maturity, data are presented showing:

(*a*) The content of N, P_2O_5, K_2O, CaO, MgO and Fe_2O_3 in the whole plant and in its separate parts.

(*b*) The uptake of N, P_2O_5 and K_2O during growth.

(*c*) The amounts of N, P_2O_5 and K_2O which would have been permanently removed from the soil if the plant had been grown and harvested in the ordinary way.

(3) These results are discussed in their bearing on the manurial practice for bananas in the Canaries, and it is shown that, having regard to the nature of the soil, the relative proportions of N, P_2O_5 and K_2O in the fertilizer mixtures in common use (moderate N, low P_2O_5 and high K_2O) are compatible with the proportions in which these nutrients were taken by the plant, and the estimated nett removal from the soil by the crop.

(4) The total losses of N, P_2O_5 and K_2O from the soil in the pit in which the banana plant was grown are estimated from analyses of the soil at the beginning and end of the experiment.

Of the estimated total loss of K_2O from the soil, which was very high, only 10 per cent. was accounted for by the uptake of K_2O by the plant. The loss of P_2O_5 was much less, but there was a

* .1 per cent. K_2O soluble in 1 per cent. citric acid before experiment and 0.068 per cent. K_2O after experiment.

† The technique used was as follows:—200 gm. of air dried soil (passing 3 mm. sieve) was loosely packed in a glass tube (2 inches diameter by 12 inches long) over a layer of glass wool. The soil was covered with another layer of glass wool. The soils were leached to one litre with an aqueous solution of carbon dioxide (made in a Sparklet syphon using one capsule in about 870 cc. of water).

‡ Soluble in conc.HCL after 36 hours' digestion.

similar relation between the estimated total loss and that represented by uptake by the plant (11 per cent.).

(5) This high loss of K_2O from the soil in question, which is of volcanic origin and very high in "available" K_2O, may be explained by the fact that K_2O is very readily leached out of the soil by carbonated water. In a comparatively short time after such a soil is taken into cultivation, under the climatic and irrigation conditions obtaining in the Canaries, it would thus be expected to have lost a large part of its available K_2O, and potash-rich crops such as the banana would need a high proportion of K_2O in the fertiliser mixtures used.

Bibliography.

1. Billings, H. E., and Christie, A. W., *Jour. Soc. Chem. Ind.*, 1917, 9, 153-154.
2. Ellis, R. H., *Jour. Soc. Chem. Ind.*, 1916, XXXV, 8, 3 & 4.
3. Hanley quoted by Ellis (*loc. cit*).
4. Ruschmann, W., *Ernahr. der Pflanz.*, 1930, 13, 298-302.
5. Holmes, E., *Tropical Agriculture*, 1930, VII, 12, 320-325.

COFFEE GRAFTING.

In a paper by F. P. Ferwerda published in *Bergcultures* VI, 1932, the merits and demerits of coffee grafting as compared with seed propagation are discussed. Advantages of grafting are: uniformity in growth and habit, less variability in yield as between individual trees (a diagram is given to show that in a certain seedling plantation under investigation, 75 per cent. of the total yield was supplied by 47 per cent. of the total number of trees; it took, therefore, 53 per cent. of the total number of trees to supply the remaining 25 per cent.); the ripening period is more defined in grafts than in seedlings, a fact which leads to economy of labour in harvesting and to control of diseases and pests attacking the berries; the possibility that by means of highly resistant rootstocks plantations can be laid out on infected land; the possibility of perpetuating a desirable variety without the mutations of seedlings; the power to transform a poor orchard into a better one by top-working the existing trees. Dealing with comparative yields it is shown by diagrams that, while seedling crops fluctuate from year to year, those of comparable grafted plantations are more regular: nevertheless, over a period of years the average yield of the grafts is considerably lower than that of the seedlings, (60 per cent.), even when the grafts are taken from particularly good parent trees, while the compared seedlings are from unselected stock.

A series of experiments in pollination revealed that Robusta coffee was self-sterile. It became obvious, therefore, that large plantations of grafted plants derived from a single clone would be naturally inter-sterile. This conclusion was emphasized by the fact that the boundary trees of grafted plantations, where those plantations joined others of different descent, would bear well, while the interior of the plantation would have but a poor crop. An instance is then given of plantations containing grafted plants interplanted either with seedlings or grafted plants from different clones, and these bear as well or better than a comparable seedling garden. The conclusions drawn are:— (1) The laying out of large single-clone plantations is inadvisable. (2) Productive grafted plantations can be made by interplanting different clones or by leaving groups of seedlings standing in the case where an existing plantation is top grafted. (3) It cannot at present be asserted that grafted plantations will yield more than seedlings, but the advantages of uniformity in various directions coupled with the fact that the produce usually commands better prices makes the method worth while. (4) Certain hybrid varieties, which are particularly fitted for districts where the standard sorts do not flourish or which have other desirable qualities, can only be propagated by grafting.— (*Plant Breeding Abstracts*, Vol. III, No. 2.)

OBITUARY.

Dr. C. A. Barber, Sc.D., C.I.E.

The death recently of Dr. Charles Alfred Barber closes another prominent career in the world of scientific agriculture in the tropics.

Born in 1860 at Wynberg in South Africa, Barber came to England in 1871. After five years' service in the Manchester and Liverpool District Bank he went to Cambridge University where he obtained first class honours in the Natural Science Tripos. In 1889 he held his first appointment as University demonstrator in Botany. He subsequently became superintendent of agriculture in the Leeward Islands (1891), and, after serving on the staff of the Royal Engineering College, Cooper's Hill (1895-1898), he was appointed Government botanist, Madras (1898). In 1908 he went to Coimbatore where he joined the staff of the Agricultural College and where, in 1912, he opened, as sugar-cane expert, the well-known Cane Breeding Station.

Barber's work will chiefly be remembered in connection with his studies of various aspects of sugar-cane production in India. His attention was first drawn to the problem of sugar-cane diseases. This was followed by a very detailed study of the Northern Indian canes which he classified according to their morphological features. It is a tribute to Barber that this classification has to this day required very little modification. The most notable cane which has resulted from crosses made by him is Co 205 whilst others include Co 210, Co 213 and Co 214. His other investigations include a detailed study of the root system of the cane plant and, during his earlier period, of the haustoria of sandal and other crops for which he gained the degree of Sc.D. In 1919, on his retirement, Dr. Barber was created a C.I.E. for his services to India and in 1931, was awarded the Maynard Ganga Ram prize for Indian research.

STRIPE DISEASE OF CORN—(TRINIDAD).

Fig. V.—Showing striping and band effect.

STRIPE DISEASE OF CORN—(TRINIDAD).

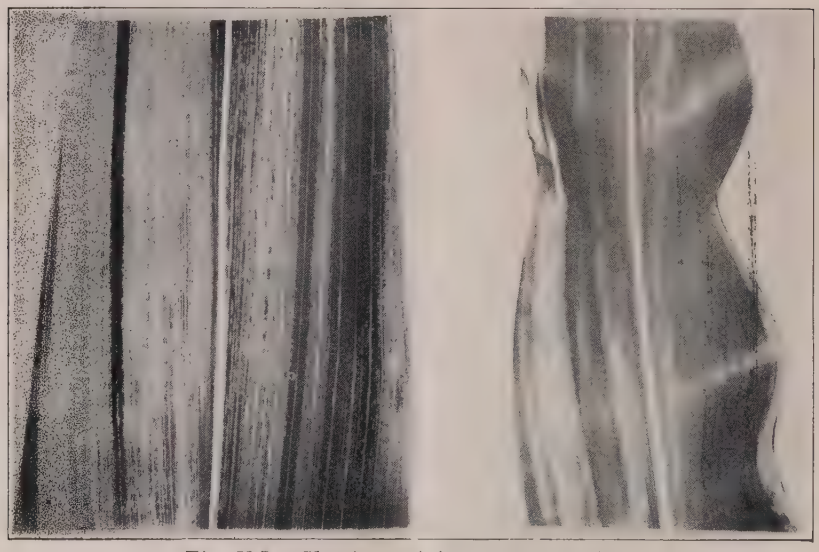

Fig. VII.—Showing striping and band effect.

Fig. VIII.—A diseased plant.

REVIEW.

WEST AFRICAN AGRICULTURE.

BY O. T. Faulkner and J. R. Mackie. *Cambridge University Press.*, 1933. pp. 164 and Index. *Price* 8*s.* 6*d.*

To one who has had a limited experience of agriculture in the tropics, but not in Africa, this little handbook appeals as being both interesting and instructive. It is written primarily for men taking up Government appointments on the West Coast of Africa and it is intended to give, in as concise a form as possible, a broad view of the existing state of native agriculture, the problems that the Administrative and Agricultural Officer have to contend with, and the lines along which improvement is to be expected. The writers point out in their preface that the subject matter is based mainly on Nigerian conditions, but is also largely applicable to the West Coast as a whole. Actually it has a wider significance. Successful candidates for appointments in the Colonial Agricultural Service are generally University trained men, with a practical experience derived mainly from farming conditions and from farming communities of the so-called civilised world. If they are to become reliable members of the Colonial Service, they have frequently to subverse much of their preconceived ideas of agricultural practice and orientate them to local tropical conditions. There is little available literature to guide them in this, and it is not strange that, in Colonial history, there are many records of improvement campaigns begun with great éclat and ending in total failure. At the present time the first aim of Colonial Governments is the moral and material advancement of the native population, as distinct from the European or Planting community by whom, in the past, many Colonies were exploited unmercifully. An intimate knowledge of native customs, psychology, and agricultural practice makes the general principles, discussed in the first section of the book, a really useful guide to any Government official working in the tropics.

Certain aspects are viewed from an unusual but striking viewpoint. For example, in the chapter devoted to Shifting Cultivation as carried out in parts of Nigeria, the possibility of this being maintained as a beneficial rotation system is mentioned.

As with any book of merit which attempts to break new ground, some sections are certainly controversial. When one considers the difficulty that has been experienced elsewhere in obtaining any conclusive results from well planned experiments on Green Manurial and Cultural Treatments, some of the statements made on these questions are decidedly dogmatic, especially where the opinion expressed is unorthodox. These statements are based on experimental results, but, as details of experiments are not cited and would certainly be out of place in a book of this nature, the reader would prefer some proof before being convinced. Or again, plough manufacturers have been particularly successful in supplying cheap light ox ploughs suited to the needs of the Indian ryot and at a price much lower than the £3 10*s.* quoted by the authors; yet, the opinion is expressed that there is quite a possibility of the primitive native wooden plough maintaining its popularity in a country like Nigeria where the white ant menace is a definite economic factor.

The second half of the book gives a very brief account of the important crops of the country, their economic value, and their future possibilities. It is therefore essentially of local interest. There is also a short chapter on Livestock, and it is enlightening to note that improvement in cattle is to be expected from selection and breeding work on indigenous herds rather than from the importation of stud animals.

The book does not attempt to be either "a text book or scientific treatise" on tropical agriculture, but it is undoubtedly of widespread interest to all workers in the tropics, and particularly to those proceeding to the West Coast of Africa on their first term of service.

D. D. P.

BOOKS RECEIVED.

We acknowledge with thanks the receipt of the following books which have been presented to the Library :—

AGRICULTURE.

Russell, Sir J.—The Farm and the Nation. *Allen & Unwin, Ltd.*, London, 1933. 7*s.* 6*d.*

BACTERIOLOGY.

Gardener, A. D.—Microbes and Ultramicrobes. *Methuen & Co., Ltd.*, London. 3*s.* 6*d.*

GENERAL.

Percy, Lord Eustace.—Year Book of Education. *Evans Brothers*, London, 1933.

PLANT PHYSIOLOGY.

Fred, Baldwin & McCoy.—Root Nodule Bacteriology and Leguminous Plants. *University of Wisconsin*, Madison, U.S.A.

James, W. O.—An Introduction to Plant Physiology. 2nd Edition. *Clarendon Press*, Oxford. 7*s.* 6*d.*

SOILS.

Martin & Doyne.—Soil Survey of Sierra Leone. *Director of Agriculture*, Freetown, Sierra Leone.

Vageler, Dr. P.—An Introduction to Tropical Soils. *Macmillan & Co., Ltd.* London. 15*s.* 0*d.*

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Spontaneous Ignition of Stored Sugar. *A. Schone.*

In a discussion of authenticated cases of the spontaneous ignition of sugar stored in bulk the author advances the theory that the primary condition for such a phenomenon is created by the spontaneous reaction between amides and reducing sugars (the so-called froth fermentation) and/or by anaerobic fermentations. Both processes are promoted by the presence of moisture, and both are supposed to result in the formation of pyrophoric masses which under favourable circumstances may absorb atmospheric oxygen with such avidity that the temperature is locally raised to the ignition point. The result is that inflammable gases, such as carbon monoxide, methane, or hydrogen, produced at the same time, may take fire.—(*International Sugar Journal*, Vol. XXXV, No. 411, p. 120.)

* * *

Advantages of the Dorr Clarifier.*

"The outstanding development in clarification equipment has been the adaptation of the Dorr Clarifier to cane sugar manufacture, and to-day more than one-third of the total production of the Islands is from factories which are completely equipped with Dorrs. Compared with other continuous subsiders which have been used at various times in local factories, the Dorr is unquestionably superior in every way.

The design of this equipment is such that it apparently avoids dead spaces in which the juice does not circulate. If pockets did exist, it would mean that some of the contents would stay in process for long periods with resulting development of acidity to the point where inversion might result. Such tests as have been made fail to show evidence of inversion either in the clear juice or the juice from the settlings when clarification is conducted at a normal reaction; thus we may conclude that the Dorr meets one of the fundamental requirements of continuous settling equipment.

Because of its compactness the Dorr may be economically fitted with high quality insulation and the heat saving thus made possible is material. The performance of this settler has been remarkably reliable and so free from disturbances which would result in the discharge of cloudy juice that it has been found possible in many places to dispense with an attendant; an occasional adjustment in the rate of draw-off of settlings is the only attention it requires.

There can be no question but that the density of settlings as discharged by the Dorr is greater than would result when working the same juices with intermittent tanks. This should be of direct benefit to the work of the filter station". Of particular interest to manufacturers of white sugar for direct consumption is the clearness and the brightness of the juice delivered in a continuous stream from the Dorr clarifiers. They are built in units of from 5 to 100 tons of cane capacity per hour.—(*International Sugar Journal*, Vol. XXV, No. 411, p. 125.)

* Report of the Committee on Recent Development in Factory Practice and Equipment, Hawaiian Sugar Planters' Association, 1930.

* * *

Impurities in White Sugars: Chlorides. *J. A. Ambler and S. Byall.*

One hundred grams of sugar were dissolved in about 150 c.c. of distilled water; about 0.5 c.c. of saturated potassium chromate solution added; and the solution titrated with 0.02 normal silver nitrate solution, as usual. Previous experiments by the authors had proved that sucrose exerts no disturbing effect on the removal of chloride ions by the silver ions. Results obtained with about 20 samples of commercial white sugars showed the Cl content to vary from 0 to 40 parts per million.—(*International Sugar Journal*, Vol. XXV, No. 411, p. 126.)

* * *

Sugar Production from Wood.

H. Claassen* lately discussed the economics of the wood sugar production of sugars. One can assume for the Scholler process a yield of about 40 per cent. of sugar on the wood, corresponding to 22.7 per cent. of alcohol; and for the Bergius process reducing carbohydrates to the amount of 60 per cent., same basis. Both processes yield syrups which are of deficient sweetness and bad flavour, and suitable only for mixing in with the usual fodders. Their value as producers of sugars for alcohol production is very uncertain, nor are they likely to be of use in producing fodder yeasts. It is concluded that the wood sugar industry cannot exist without protection.—(*International Sugar Journal*, Vol. XXV, No. 411, p. 122.)

* Chem Zeit., 1932, LVI, pp. 989-991.

ERRATUM.

The Flood Fallowing of Cane Fields in British Guiana.

Page 92, Column 1, Line 46: For "That a more marked response is obtained from fields further aback" read "That a more marked response is obtained from fields *nearer the coastline than* from fields further aback".

CHEMICAL NOTES

Compiled by the College Department of Chemistry and Soil Science.

Palm oil for Fattening Poultry.

The Imperial Institute was recently consulted by the Malayan Information Agency regarding the suitability of Malayan palm oil as a substitute for mutton fat in the fattening of poultry. As there appeared to be no record of the use of palm oil for this purpose arrangements were made with Mr. E. T. Halnan, of the Animal Nutrition Institute, Cambridge, for a feeding trial to be carried out. The sample of oil used in the experiment was supplied by the Malayan Information Agency and represented the best grade of palm oil produced on plantations in Malaya. The results of preliminary trials were quite favourable, and it is now proposed to arrange for a commercial test of the oil.—(*The Bulletin of the Imperial Institute*, Vol. XXX, No. 3.)

* * *

Growth of Young Tea-Plants.

A large series of pot-experiments* were carried out in the experimental garden of the Tea Experiment Station at Buitenzorg, the soils used being obtained from different tea-estates. The pots were placed in a slightly shaded plot under natural conditions. They were filled with soil mixed with different quantities of powdered lime of sulphur, in order to vary the degree of saturation and the pH value, and after three to four weeks the tea seeds were planted. At the end of the experiment, the average height and the weight of leaves and roots were determined for each plant.

The results showed that in no case did the addition of lime have any favourable effect on the growth of the plants, but, on the contrary, the greater the amount of lime which was added the more the growth was decreased. In pots with an alkaline soil the percentage of undeveloped seeds was noticeably greater than in those pots to which no lime had been added; moreover, at later periods many plants died. On the other hand, the addition of sulphur definitely increased the growth of the young plants, which had a healthy appearance and possessed a well-developed root-system. Mixtures of lime and sulphur were only found to stimulate growth when the proportions were such that the concentration of the hydrogen-ions in the soil was increased and the degree of saturation diminished.

Although primarily the favourable effect of sulphur-manuring is due to the increase of the hydrogen-ions and the decrease of the exchangeable bases in the absorption complex, it is pointed out that sulphur-manuring has secondary results, such as changes in the physical and chemical conditions of the soil. The good results with sulphur-manuring on some soil types depends to a great extent on the degree of intimacy with which the sulphur is mixed with the soil. It is suggested that in practice sulphur can be used not only in nurseries but on new plantations, by mixing the sulphur with the soil when setting out the young plants.

From the results obtained it does not necessarily follow that mature tea has the same requirements as young plants and hence experiments in the field will be required to determine the influence of the degree of saturation of the soil on the productivity of bearing estates and on the quality of the manufactured tea.—(*Abstracted from the Bulletin of the Imperial Institute*, Vol. XXX, No. 4)

* Prillwitz, P. M. H. H.—*Archief voor de Theecultuur*, No. 2/3, pp. 1-122.

* * *

Sugar-Cane Manuring in Leeward Islands.

In Antigua the application to sugar-cane of a light dressing (1,200 lb. per acre) of super gave a crop of 39.5 tons, whilst a heavy dressing (3,600 lb. per acre, gave a crop of 40 tons as compared with 34.4 tons for the crop receiving no P_2O_5. The increases of 5.1 and 5.6 tons were significant. In St. Kitts-Nevis statistically significant differences were found between yields of ratoon canes receiving 40, 80 and 120 lb. per acre N. The 80 lb. dressing was most profitable. Additional small increases were given by K_2O and P_2O_5 but were not significant. The residual effect of 25 tons per acre farmyard manure or 12½ tons farmyard manure plus artificials supplying 20 lb. N, 30 lb. K_2O, 20 lb. P_2O_5 was significant, whilst 600 lb. Humber fish manure had no residual effect. An application of 12½ tons farmyard manure plus a small dressing of artificials was more profitable than 25 tons farmyard manure.—(*Abstracted from Bulletin of Imperial Institute*, Vol. XXX, No. 3.)

* * *

Chemical Composition of the Mango.

The chemical composition of the fresh pulp of mango fruit has been determined by R. Yamamoto, Y. Osima and T. Goma (Tokyo Institute, Scientific Papers, 1932, Vol. 19, p. 122), who have reported the following data. The water content of the pulp is 81.7 per cent., and the sugars consist of sucrose (5.5), fructose (4.9), and glucose (1.5). The acidic taste is due to citric acid (0.5), and the yellow colour, to xanthophyll (0.9) and carotene (0.1). The last-named substance, isolated from mango fruits, was found to curve avitaminosis-A in rats, and therefore confers a valuable food property on the fruits. (*British Chemical Abstracts*. (A), Nov. 1932, p. 1178.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

	Foreign.	*Preferential.*
	s. d.	*s. d.*
23rd Feb. ..	5 6	10 3
2nd Mar. ..	5 9¼	10 5¼
9th Mar. ..	5 9⅞	10 7½
16th Mar. ..	5 11¼	10 9
23rd Mar. ..	5 10½	10 8¼
30th Mar. ..	5 11¼	10 9
6th Apr. ..	5 9¾	10 6¾
(*7th Apr.*, 1932) ..	4 3¾	8 1½

One of the features dominating sugar prices has been the monetary crisis in America which has been followed by comparatively sharp price fluctuations. The course of the market during the past two months, according to *C. Czarnikow, Ltd.* has, however, certainly demonstrated the increasing confidence inspired by the improving sugar position. The article moreover has been for some time moving towards a sounder statistical position brought about by restricted production in European exporting countries as well as in the large 'free' market cane producing areas. The Raw market has maintained its firmness.

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :—

	American Mid.	*Egyptian F.G.F. Sakel.*
24th Feb. ..	4.95	7.02
3rd Mar. ..	4.79	6.84
10th Mar. ..	5.17	7.21
17th Mar. ..	5.26	7.29
24th Mar. ..	5.13	—
31st Mar. ..	5.15	—
7th Apr. ..	5.28	—
(*8th Apr.*, 1932) ..	4.73	6.55

Prices which have shown a certain advance have been governed to a large extent by the American situation. There was an improved demand for West Indian Sea Island during the middle of last month.

* * *

LIME PRODUCTS.—*Lime Oil.*—Buyers show no interest yet and there is now no shortage of supplies. Hand-pressed is nominal at 55*s.* and distilled at 35*s.* to 37*s.* nominal.

Lime Juice.—Raw is quietly steady but there is little doing. The last price of good West Indian was about 2*s.*—(*West India Committee Circular*, 16th March.)

COCOA.—Stocks of cocoa in licensed warehouses in the U.S.A., the principal consuming country, still remain exceedingly high, but the market there has been, if anything, steadier, no doubt due to the fact that the arrivals of Accra cocoa for the month of March were slightly under 70,000 bags or 343,000 bags less than the corresponding period in 1932. This makes the total landing of Accra cocoa in New York for three months 467,000 bags against 845,000 bags last year or about 55 per cent. less. On the other hand, United Kingdom-Continent continue to report a very dull market with values slightly under what they were a month ago. Those are as follows :—

Trinidad fine Plantation 36 to 49*s.*, Grenada 33*s.* to 34*s.*, Venezuela fine unclayed 70*s.*, Accra good to fine fermented 32*s.* to 24*s.* 6*d.*, Ceylon good Plantation 43*s.* to 47*s.* and in Trinidad $4.80 a fanega.

On the whole there does not appear to be much chance of any improvement until general economic conditions improve.—(*By courtesy of the Cocoa Planters' Association of Trinidad, Limited.*)

* * *

COPRA.—Copra is quiet with West Indian f.m.s. quoted at £12 15*s.* to £12 17*s.* 6*d.* c.i.f. London April-May shipment.—(*West India Committee Circular*, 16th March.)

* * *

BANANAS.—Jamaicas are in slightly better demand, and the price is £2 per ton higher at £20 5*s.* delivered London, and £20 nearest railway station. Brazilians are unchanged at £18 per ton nearest station.—(*West India Committee Circular*, 16th March.)

* * *

COFFEE.—Since the beginning of March there has been a steady rise in Costa Rica and Kenya prices, latest quotations for the former being 120*s.* per cwt. up to 138*s.* per cwt. A parcel of Jamaica bold mountain coloury fetched 214*s.* 6*d.*

* * *

TEA.—Latest quotations which show a decline include Ceylon at 14.40*d.*, Indian at 10.33*d.* and Java at 6.78*d.*, the Darjeeling average being 14.16*d.*

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows :—

	d.
22nd Feb.	2 3/32
1st Mar.	2 1/32
8th Mar.	2 1/8
15th Mar.	2 1/8
22nd Mar.	2 1/8
29th Mar.	2 3/32
5th Apr.	2 3/32
(*6th Apr.*, 1932)	1 13/16

Conditions in the market have not altered materially since the last Report, being generally quiet. There was a little buying by America after the reopening of markets there and also some buying by Home Trade interests. The total consumption in America for 1932, was 314,619 tons or 32,065 tons less than in 1931.